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SUPPLEMENT TO "THE ELECTRICAL ENGINEER," DEC. 29, 1893.

THE

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THE

ELECTRICAL ENGINEER.

No. 1, Vol. XII. LONDON, JULY 7, 1893. PRICE 3D.

NOTES.

Salzburg.—On Sunday, 30th ult., the electric railway up the Mönchsberg, in Salzburg, began running from seven in the morning to eleven at night.

French Accumulators.—The series of lawsuits brought by the Société Française d'Accumulateurs Electriques is ended. All the makers of accumulators have had judgment pronounced against them.

Ashton Technical School.—On Saturday the Heginbottom Technical School was opened at Ashton-under-Lyne. The school has been built with a bequest from the late Mr. George Heginbottom of £10,000, with an additional £3,000 from the Corporation. The new school is well equipped for science teaching.

Telephone to the Summit of Snowdon.—Sir Edward Watkin, Bart., M.P., is now in course of fixing a telephonic wire between the summit of Snowdon and the post office at the Vale of Gwynant, on the picturesque slope of which his beautiful châlet stands. The service was opened yesterday, in celebration of the Royal wedding.

South London Electric Railway.—Some readers may have noticed, without enquiring into details, a reference to an accident upon this line. The accident had nothing at all to do with the electric working, but was a mishap to one of the lifts, caused by a rope breaking. The passengers in the lift at the time, though much shaken, were not injured.

Royal Institution. — The special thanks of the members of the Royal Institution have been returned for the following donations to the fund for the promotion of experimental research at low temperatures: Ludwig Mond, Esq., £500; Robert Hannah, Esq., £50; Sir Walter Gilbey, Bart., £21; Henry Arthur Blyth, Esq., £21; James Blyth, Esq., £21.

Financial Results of Walsall Tramways.—At the annual meeting of the Tramways Institute last week, Mr. A. Dickenson, of the South Staffordshire Tramways, said that he hoped at the next meeting to give the results of the working of the Walsall electric tramways, and which he believed would convince anyone that the overhead trolley system was the best method commercially.

Testing Institute.—An electrical testing establishment, the first of its kind in Scandinavia, has been opened in Stockholm by Herr Axel Estelle, a well-known Swedish electrical engineer. The establishment, modelled on the Physikalischtechnische Reichsanstalt, in Berlin, undertakes the testing of electric apparatus by instruments supplied by the institution named, the drafting of plans for electrical installations and estimates, and so forth.

Station Testing.—M. Desruelles (36, Rue de la Boetre, Paris) have recently produced a testing set of considerable convenience and small size. The set contains an astatic galvanometer (Nobili) of great delicacy, a Wheatstone bridge, a box of resistances (12 coils), a double-contact key, terminals, and a battery of eight cells of Street and Desruelles's pattern, hermetically closed. A drawer is added for pen, ink, paper, and note-book.

Coast Communication.—Telegraphic communication has been established with Lundy Island. This is one of the important firstfruits of the report of the Committee on Coast Communication. The island forms a natural refuge in rough weather, and it has been no uncommon thing for a score or two of vessels to lie storm-bound in the lee of Lundy, while for days the gravest anxiety prevailed in regard to them in the Bristol Channel ports.

Water Connection.—From Havana a curious accident is related, occurring to the lighting cable crossing the San Juan river at Matanzas. A long span was used, and one night one wire burnt off, and both ends fell into the water. Flashing was noticed, but in the station and the city no change was observed in the lighting, so it was left till the morning, when the wires were spliced. The lighting current had gone through the water all night.

Krebs Telephone Transmitter. — Commandant Krebs, major of the Sapeur-Pompiers (Fire Brigade) of Paris, has devised a convenient magnetic telephone transmitter, by which notice of fire can be transmitted instantaneously to the brigades and police stations. The transmitters are placed under the fire alarm posts, and can be spoken through when the glass is broken. The officers carry a portable transmitter for testing the alarms.

Electric Launch at Bath.—An electric launch, owned by Mr. Ernest Pitman, took a party of local newspaper representatives a trip from Bath to Saltford last week, under the direction of Mr. Metzger, engineer and manager of the Bath electric light works. The launch is provided with accumulators to run 35 miles at five miles an hour. The "White Swan," as the launch is called, took the party a very enjoyable run in spite of rough wind. Mr. Pitman's boat has room for 10 persons, and the Bath Electric Lighting Company are willing to supply pleasure-boats, recharging them when occasion requires.

New Theory of Electrostatics.—M. Vaschy (Académie des Sciences, June 5) proposes to show that the theory of electrostatics can be established on simple experiment and reasoning, leaving aside the hypotheses which, in present theory, seem indispensable—viz. (1) actual existence of electric masses acting on similar masses and even, according to certain physicists, on ponderable matter; (2) extension of Coulomb's law $\left(f = \frac{m\,m'}{r^2}\right)$ on reciprocal actions of these masses; (3) the hypothesis of induced electrification in dielectrics.

Canal Trolley Traction.—The scheme for running canal boats by overhead electric trolley traction seems to be taken up with some promise of success in America. Governor Flower has undertaken to champion the cause of the trolley canal boat. He has suggested an appropriation

for the purpose from Congress, and the superintendent of canals, Mr. Hannan, is prepared to receive plans and suggestions. The problem is to supply power in small units (25 h.p. to 100 h.p.) along a line 300 miles in length. Governor Flower thinks the whole cost would not be over a million dollars (£200,000) to fit 12 power-houses 30 miles apart, and the cost 2s. 6d. per day per boat. It is thought by electrical engineers that this estimate is too low in both cases, but that the project is worthy of attention.

Electro-Hygiene. — Mr. Newman Lawrence's new venture, *Electro-Hygiene*, the electro-medical paper, has, it appears, achieved quite a success, for the first edition went into a second edition. Amongst medical men, nurses, and those interested in the application of electricity to medicine it will certainly do good. A forcibly-written criticism on the backwardness of the medical journals in general, and the *British Medical Journal* in particular, in dealing with electropathic belt and similar quackeries, is given in the second number. While they hung back the *Electrical Review* stepped in, and "as it is now, the medical profession and the public have to thank the electrical journals, and not the medical, for the instructive lesson on electropathic belts given by the recent proceedings in the law courts."

Marriage-Day Illumination. — The Edison and Swan Company will display at their head office, Victoria-street, an immense radiating star, bulging to a central circle, enclosing the letters "V.R." and "G. M." The star is of 50ft. circumference, and built up of a thousand 8-c.p. incandescent electric lamps of various colours. The current is supplied from Deptford by the London Electric Company by special leading wires from their mains. The *Illustrated London News* has arranged with Captain Ronald Scott for a searchlight projector, with which portraits of Prince George and Princess May will be projected on the clouds to the delectation of the populace. Other large electric illuminations are to be seen along the line of the procession, considerable advantage having been taken of the electric companies' mains.

Electric Interference in a Liquid Layer.—To produce electric interference, M. R. Colson (*Comptes Rendus*) uses a Ruhmkorff coil fed by a thermopile. The ends of the two copper wires from the coil are in contact with a moderately conducting layer, formed by a liquid cooling on a glass plate. The two contacts form two poles, whence the electric flux is propagated in the liquid coating in periodic circular waves. A telephone is used with a contact movable in the liquid layer, the other contact being insulated and in connection with a constant capacity. In this manner the neutral point can be examined, as in wires, as the perception of the minimum sound is perfectly distinguishable. A series of points is thus obtained giving a neutral continuous line whose form varies according to the nature of the liquid, the distance separating the two poles, and the strength of the current passing.

Electric Time.—One of the most convenient methods of distributing the correct time is evidently by way of electric control. Moreover, the control itself may be made to work the movement of the clock hands with very little mechanism save an electromagnet. Such a system is in use in the General Post Office. The system is carried out to a considerable extent in New York by the Time Detector Company, 234, Broadway. Mr. J. S. Morse has perfected both a self-winding regulator electric clock and the secondary dials (illustrated in *Scientific American* for 17th inst.). The regulator has a full-length pendulum beating seconds wound by electricity—that is, self-winding. The circuits are connected so that every dial can be set by a key in the regulator. A gauge is also in circuit, showing the state of the battery, so adjusted that a bell rings when the battery weakens. Hundreds of dials have been in use for years, it is said, without once giving inaccurate time.

Train-Lighting.—The De Meritens primary battery was recently tried for a few months on the French Chemin de Fer de l'Est and de l'Ouest simultaneously. The elements of this cell comprise a plate of zinc between two platinised lead plates, the latter pierced with holes to facilitate the disengagement of the hydrogen. The liquid is one part sulphuric acid to four of water. Nine elements are placed in one cell within a box. Each car carries two similar boxes, with a commutator to allow the elements to be grouped by 14 or 18. Each compartment has two lamps—one plain and the other red—the latter being lighted automatically when the white lamp fails. An hour-meter is attached to indicate the time the lamps are burnt, and consequently when the batteries require recharging. The 18 elements weigh 120 kg. (264lb.), and will light the three lamps of the car for 48 hours, lighting at 10 volts and 1·6 amperes. The experiments have, however, been abandoned.

Electrolytic Production of Zinc.—A process has been developed for converting blende (sulphurated zinc) into soluble salts of zinc and electrolysing the latter in an electrolytic bath. The cathode is formed of zinc or another metal not affected by the process; the anode is of iron or other metal not zinc. The electrodes are separated by a porous partition. The cathode is surrounded by a water solution of a zinc salt; for instance, sulphate of zinc obtained from sulphurated zinc by chemical or metallurgical means. The anode, on the other hand, is surrounded by a solution whose positive component is a salt of the metal employed as anode, and whose negative component is of the same acid as that in the zinc salt to be electrolysed. When the liberated acid forms during electrolysis insoluble salts by combining with the anode, the above-mentioned porous partition is suppressed, and both the cathode and anode are surrounded by the zinc salt to be electrolysed.

A Castle in the Air.—The great exhibition which is to take place next year at Antwerp will boast a literal castle in the air. A company has been formed to carry out the plan of M. Tobianski, an ingenious engineer, who has designed a sort of raft, having an area of about 180 square feet, and made of bamboo canes and steel and aluminium piping. Upon this is built a most luxuriously fitted-up restaurant. The raft is held floating in the air 500ft. above the ground, by a number of balloons; and an arrangement of anchoring by means of cables will (so says M. Tobianski) prevent the restaurant from rocking even in the strongest wind. Two small captive balloons, each holding from eight to ten persons, will serve like lifts to keep up communication between the aerial restaurant and the earth. There is a regular system for supplying gas to the balloons, and at night the exhibition will be lit up by an immense electric light projected from the raft. The whole thing can be lowered to the ground within 10 minutes by specially constructed windlasses.

Conjoint Resistances.—A simple method of measuring conjoint resistances of circuits is given by Mr. W. C. Ramsdell (New York *Electrical Engineer*), often preferable, he considers, to the usual methods (*a*) of dividing the product of their resistances by the sum (any two conductors at a time), or (*b*) the "reciprocal" method, which is to add the reciprocals of the resistance of each conductor, and the sum is the reciprocal of the joint resistances. By the third method (not hitherto published, he thinks) the conjoint resistance is found by dividing an assumed E.M.F. by the sum of the currents which would be produced in the given conductors, thus

using nothing but Ohm's law. The calculation is simplified by taking an E.M.F. which is a common multiple of the resistance. Thus, given five conductors of 2, 3, 4, 5, and 6 ohms respectively, to find their joint resistance. The least common multiple is 120: then, assuming 120 volts, there would be currents of 60 40, 30, 24, and 20 amperes. The sum of these is 174 amperes and $120 \div 174 = \frac{20}{29}$, which is the joint resistance of the five conductors. The superiority of this method is quickly seen when the attempt is made to calculate the joint resistance by either of the old methods.

Electrolytic Action on Water-Pipes.—One of the pressing questions which are being discussed in America is that of the electrolytic action by the current from trolley tramways on the gas and water pipes. There seems to be real cause for anxiety according to certain accounts of accidents which have already happened. In Illinois, an overhead line became grounded through one of the iron poles carrying the span wires. The base of this was in contact with an abandoned cast-iron gas-pipe, both being somewhat rusted. In crossing, an arc was formed, practically welding the two together. It is said the current then followed the old pipe 100 yards, where the cast-iron pipe encountered a wrought-iron natural-gas main. Here the same thing occurred: the pipes were melted and an opening formed so that the gas entered the old pipe, which followed to the base of the iron pole. Here it caught light and issued at the top in a flame 15ft. high, quickly melting the trolley lines and interrupted the traffic. This accident was more due to the heating effect than to electrolysis. But in Battle Creek, Michigan, a wrought-iron coated service pipe (water) taken from the earth in front of the street railway power-house, 3ft. below surface, showed an extraordinary appearance. It was eaten to bits with large irregular holes all over it. The tramway system was the usual overhead trolley with grounded circuit, having been in operation 18 months.

Gas-Engine Generators at Lille.—The day of large gas-engine plants seems beginning. We have one or two examples in England, and in Lille, in France, there is a typical example. The Société Lilloise d'Eclairage Electrique will have for its station plant three Otto gas-engines of 110 h.p. to 120 h.p. Each engine will drive two Rechniewski direct-current dynamos. A battery of accumulators, with a normal output of 50 kilowatts, will be installed. Each dynamo will give 288 amperes at 125 volts, or 36 kilowatts. The mains will be underground on the three-wire system. The cables will be heavily insulated and double-armoured, and laid in a thick bed of sand. At crossings culverts will be formed. There will be three sets of feeders. The pressure will be 114½ volts to give 110 volts with a drop of 4½. The choice of gas for motive power has been brought about by an able paper by Prof. Witz, of Lille, which went to demonstrate that gas-motors would one day supplant steam-engines, and that at present there is not economy, but the reverse, in using steam-engines. There is also the reason that the town has a royalty of $\frac{1}{10}$d. per cubic metre of gas sold, which doubtless told towards the choice of gas-engines. The larger streets of Lille will be lighted by arc lamps, and there is a good field for private lighting. Engineers discussing different systems of plant would do well to keep informed of the progress of this installation.

Nantes.—The town of Nantes has been recently lighted by electric light on the low-tension system with accumulators. The batteries are placed in sub-stations, and the distribution is on the three-wire system. The generating station is in the Rue Sully, about 160 yards from the small river Erdre. The dynamos are five in number. Three engines are used—one of 75 h.p., Weyher et Richemond, and the two others, of 120 h.p., were made by Voruz, of Nantes. The engines are coupled to the dynamos by Raffard couplings. The 75-h.p. engine drives a dynamo giving 200 amperes at a pressure varying from 250 to 330 volts; the two other machines drive dynamos giving 270 amperes at the same voltage. The current from each machine is taken to a switchboard, whence it can be sent either to the accumulators at the sub-station in the Rue Calvaire or to the station battery. The batteries at the two stations together can supply 1,000 amperes at 220 volts for three hours, which is sufficient for 6,000 10-c.p. lamps. The total number of lamps is 8,000, but never more than 70 per cent. are lighted at the same time, and the accumulators can therefore easily supply the lighting for one evening. The engines are only run during a portion of the day. The mains are entirely underground; bitumen conduits take the three-wire conductors and a feeder. The service mains, in iron pipes, are connected direct to the mains; a service box contains two fuses at the junction.

Electro-Metallurgy.—The Central News says: "At the Institute of Mining and Metallurgy, Jermyn-street, on the 28th ult., Mr. J. D. Hannay, of Cove Castle, Loch Long, laid before the members the last instalment of the scheme of metallurgy which he has been unfolding for some years, and one branch of which he recently communicated to the Royal Society. The paper dealt with the refractory ores of gold, which, now that alluvial deposits have been wrought out, constitute the whole future source of gold. Mr. Hannay remarked that in all our colonies mines yield refractory ores as they reach deeper levels, and the impossibility of extracting their gold at a reasonable cost had driven many miners to the conclusion that the prosperous period of gold-getting was over, but as the gold is there in as great a quantity as ever, although beyond the reach of known processes, chemists have always hoped by some simple discovery to extract the gold cheaply, and thus renew the palmy days of early prosperity. The process which Mr. Hannay described, and by which at the cost of a few shillings per ton, he can electroplate the gold out of any ore in a few hours, offered, he maintained, a complete solution of the modern difficulty. The apparatus was described as being of extreme simplicity, one vat being capable of exhausting 10 to 20 tons of ore in three to four hours, while the gold and silver are all obtained in the metallic state as an amalgam. The process, as shown by tests made by the assayer to the Bank of England, deals so efficiently with ores of every degree of refractoriness that any variation in the ore—common occurrence in the course of mining—does not affect the yield of gold by this process."

Omnibus-Lighting.—The views of Mr. Freund, as expressed in his paper before the Tramways Institute, must be taken with caution. For the past 12 or 14 months we have narrowly watched the experiment of lighting London omnibuses. Two firms are doing this work—viz., Mr. Bristöl and the Lithanode Company. Unfortunately, neither of these firms have issued an authoritative statement as regards the actual cost of the work. Indeed, the Lithanode Company is not in a position so to do, as the apparatus manufactured by it was manufactured simply to the order of Mr. Willing, who contracts for the lighting of certain 'buses. All that the Lithanode Company has done has been to charge the batteries for a certain payment per week. We are told that the batteries used act admirably, and the plates used are mechanically and electrically as good now as when put in. So far as we can gather, Mr. Bristol

hires out his apparatus, and has not sold any. Therefore he would be in an excellent position, if he chose, to give an authentic history of the total cost: initial, maintenance—everything; also the communications which have passed to and from him with regard to the light. Rumour says the matter is not quite satisfactory; but it would be advantageous to have facts—not rumours. The estimate as given by Mr. Freund is to our mind misleading. One item can be checked, and if on so important a point there is incorrectness, we must take it that the estimate is merely an estimate, and intended to attract rather than to prove. Can any incandescent lamps be supplied at 1s. 6d. each in this country at the present time? If, then, there is an error in this one item alone of from £60 to £70, what value can we place on the whole estimate? It is not assisting the industry to promulgate information that cannot be substantiated, and these statements make it doubly hard for legitimate traders to do real business.

Electric Traction and the Telephones.—Mr. F. F. Bennett, of Preston, in a letter to the *Manchester Guardian* recently, gives a number of statistics as to the cost of working telephone stations. He suggests that any corporation, in return for allowing a company to put its wires underground, should have their telephones free. He then deals with the question of interference, saying: "If we are in this country to enjoy the great advantages of electric traction, I consider that there is no alternative but to have a complete reconstruction of our telephone system. The present obsolete method must give way to the more modern and perfect one of metallic circuits, thus ensuring the electrical non-interruption of both industries, and so improving that of the telephone as to entirely do away with bad speaking, overhearing, noises, and other inductive abominations. It is assumed that the difficulty can be overcome by the electric traction people using a metallic return, but there are considerable practical difficulties in the way of this. My own experience goes to prove that where a centre underground channel is used containing one conductor with an earth return great trouble is experienced in keeping that bare conductor properly insulated. In the case of the Blackpool tramway short circuits were occurring at first very often, especially when the collector or slipper passed over junction and facing points. By dint of dogged perseverance this trouble was subsequently reduced to a minimum, and now similar faults very seldom occur. Imagine, therefore, the difficulty of coping with two underground bare conductors (which must be kept highly insulated and in close proximity) instead of one. It may be argued that one of the conductors could be placed overhead on the American plan. Assuming that this would get over the difficulty, I am certain that it would not be allowed by the ruling municipal authorities." In conclusion, Mr. Bennett draws attention to the fact that the Post Office are about to acquire the trunk wires over the kingdom, so that no difficulty would be likely to arise in the matter of inter-town communication in the event of other companies forming, as the Post Office would allow facilities for trunk-wire speaking to all."

Ayrton and Mather's Galvanometer.—The new form of d'Arsonval galvanometer, devised by Prof. Ayrton and Mr. Mather, is fully described in its practical form in the price-list issued by Mr. R. W. Paul, of Hatton-garden. There are several points of much interest in this moving-coil reflecting galvanometer, and we see that a number of them have been supplied to the technical colleges—Cambridge, Nottingham, Liverpool, Manchester, etc.—to the physical science professors. A coil of wire hangs in a powerful field whose lines are parallel to the plane of the coil, on passing a current through the suspensions the coil is deflected through an angle which depends on the strength of the current. A very long, narrow coil, of cross-section of two circles touching, is adopted on mathematically-determined principles. This coil is for a dead-beat instrument, enclosed in a tube of silver; when it moves, the Foucault currents generated tend to bring it to rest. For a ballistic galvanometer no such tube is used. The suspension has been carefully tested to avoid tilting, the system adopted being to have the coil freely suspended from above, while the continuity of circuit is maintained by a light flat strip spiral attached to an insulated pin at the lower end of the coil-tube. An outer brass tube protects from injury, and a clamping device enables the galvanometer to be easily transported. A substantial brass base-plate carries the whole, furnished with levelling screws. A strong permanent magnet is bolted thereto in the form of a cylinder: it bears a circular spirit-level for adjustment. Interchangeable coils are supplied. The radius or scale distance of the mirror is usually 3ft. The stock pattern, having an aperiodic coil of 325 ohms resistance, gives with one-millionth of an ampere about 10 millimetres deflection on the scale at one metre distance. Greater sensitiveness can be obtained, but this is amply sufficient for all ordinary purposes. The ballistic coils have a period of about three seconds. By winding the coils with two similar wires, through which currents can flow in opposite directions, a very sensitive galvanometer is produced in which the slightest difference of current in the coils gives a large deflection. Scales, keys, and shunt-boxes are also supplied for the various tests carried out by reflecting galvanometers. The price is very low compared with some forms, and the size in travelling-case is about 7in. cube. It is an exceedingly useful form of reflecting galvanometer.

Artistic Fittings.—"A thing of beauty is a joy for ever," sang Shelley in one of his best-known lines, and nowhere is it more true than in one's house. To be able to live with it is the supreme test of a good picture, and it is the same with the house decorations. We have often dwelt upon the desirability of electrical contractors cultivating to the utmost the æsthetic side of their work. It will be found to pay to have a skilled decorator of high taste to consult with the heads of households, as well as an engineer whose evident knowledge of exact requirements inspires confidence in the machinery. Among the producers of highly artistic electric fittings the firm of Lea, Sons, and Co., of Shrewsbury, have for some time taken high place. Glimpses have been seen in showrooms and exhibitions of delicately-wrought leaves and sprays prettily adapted to electric light. The firm have issued a catalogue very handsomely and carefully arranged. The designs are printed in silver and gilt toned ink on separate sheets, and each design is hand-tinted in their colours. The result is charming from the catalogue point of view, and put into the hands of any lady of the mansion must make her long for her house to be so fitted. When this stage arrives the battle is over; and when a person is thinking of having electric light, designs of this kind are just those to bring the thought to a resolution. Several sheets of simple designs are given, but those shown on sheets 1 and 4, for instance—china painted jar with metal wrought sprays and electric flowers, candle-brackets, leafy pendants, and standards—are fine specimens of the floral electric fitting. There are several styles—the metalli-floral may be varied with the cord pattern, where the electric globes hang on gilded cords from delicately-wrought pendants in metal. The lists are only an indication of the wealth of designs that can be furnished. All the fittings are wired so that the wires can be withdrawn for inspection or repair. A

ball or hollow body usually supports the arms; inside the ball are metal rings on a vulcanite or slate base, to which the wires are attached, and when the upper half of the ball is raised the wiring is exposed. The fittings are made in iron (black or bright), bright iron and blue steel—a very artistic combination—polished brass, brass and copper, gilt and silver. We notice that a spray of any metal or combination will be sent on application at 5s. a spray, so that colours and effects can be tested. This list of fittings is one which should be in the hands of all who fit up high-class houses.

Electro-Photography.—Mr. David E. Packey, of Birmingham (who writes his experience in the *English Mechanic*), thinks he has discovered a new science—a "new field of astrophysical research." This is in photographing the "electric rays" of the spectrum. He does this by causing an electric current to pass over the photographic negative during exposure, and he obtains a "secondary spectrum." The ordinary spectrum is very slightly deflected by the current; but on development a second faint spectrum is seen of rays wholly contained in the ultra violet portion beyond the H and K lines considerably deflected by the action of the current. It is so faint that the other portion must be considerably over exposed to develop it. This secondary spectrum he has denominated the "electrical spectrum," the action of the current "tending to deflect all rays in the sun's light due to electric energy, and so isolate them from the rays due to chemical energy, and always in a direction parallel to the current. When the electric current was applied to a sensitive plate exposed to the image of a star's light, and stationary so as to form a trail, the resulting image was somewhat deflected from its normal position whenever the circuit was complete, returning to its normal position when the circuit was broken, and showing an increased intensity in the chemical action at the ends of the broken trails." The method adopted of causing the current to affect the plate was by placing the sensitive plate with its film side away from the object-glass, and backing the film with a sheet of tinfoil, the ends of which, projecting from the movable back, enabled a connection to be easily made with the wires of a battery, and thus completing the circuit. A single two-volt cell with zinc and carbon elements completed the apparatus employed. The plates were developed in the ordinary way with hydroquinine. Every care was taken to prevent any false images due to reflections, halation, etc., from being confounded with the electrical images. Photographs were taken of the same objects without the interference of the current as a check on the results obtained. The idea in these experiments is, apparently, that if there is any definitely electrical action in photography it will be deflected by a steady current at right angles; there would then be a sifting of the various rays, and comparison might give extra data for study of star distances. Any celestial photograph would thus have double value. There is something hazy in the reasoning; but if there is such an effect as deflection of spectrum rays by a current, this phenomenon requires studying.

Effective Alternating Currents and Electromotive Forces.—Mr. A. E. Kennedy (in the *Electrical World*) gives some clear remarks on the terms "mean current," "square root of mean square," and "effective current," as applied to alternating-current circuits. Suppose, he says, that in a circuit we have a current alternating between the limits of 10 amperes positive and 10 amperes negative, say, 200 times in a second. The mean or numerical average current strength will be some value between 0 and 10, depending upon the shape of the current wave. With a simple zigzag wave, the mean current would be 5 amperes, for semicircular waves 7·854 amperes, and with sine waves 6·367 amperes. But in the most important practical applications of electric currents, the effect depends upon the square of the current strength. The rate of developing heat in a constant resistance is a prominent instance, and incandescent lamps may be practically included in the same category. When the current through such a resistance is doubled, the rate at which the heat is generated therein is quadrupled. If the current periodically alternates or fluctuates, the same quantity of heat will be developed in a given interval of time (including many cycles), if the average square of the alternating current is equal to the square of the uniform continuous-current strength. Just what maxima the cycles will reach when this condition is maintained will depend upon the shape of the current wave; but if the wave happens to be a sinusoid, with a maximum of 10 amperes, whose square is 100, the mean square over the cycle is just half this maximum square, or 50, and the heating effect of this alternating current would be equal to that of a continuous current whose square was 50—that is, whose strength was 7·07 amperes. The "effective" strength of any fluctuating or alternating current is thus the square root of its average square, and if we know this effective strength, we know the heating power of the current without requiring any knowledge of the wave shapes. The mean strength of a current measures, then, the quantity of electricity that would flow through the circuit in a given time, without regard to direction. The "effective current," or square root of the mean square, measures the thermic activity that the current will develop in a resistance. The mean strength of an alternating current would be indicated by a D'Arsonval galvanometer if the waves were all "rectified," or delivered to it in the same direction with the aid of a commutator. The "effective" current strength would, on the other hand, be indicated by an ammeter of the dynamometer type, with or without rectification, since the deflections of such instruments are independent of the direction, but proportional to the square of the traversing current's strength. If this square fluctuates, they point out the average square. Similarly, the "effective" voltage of a periodically varying E.M.F. is equal to that uniform continuous E.M.F. which, applied to a simple non-inductive resistance, would generate therein the same amount of heat in a given time sufficiently long to include a number of cycles and obtain a fair average. Since the thermal activity of an E.M.F. applied to a fixed resistance is proportional to the square of the voltage, the effective value will be the square root of its average square. The term "effective," chosen by the Paris Congress of 1889, may be understood as "effectively equivalent in thermal activity." All alternating-current voltmeters and ammeters are in practice calibrated to "effective values." By this means an incandescent lamp which is brought to full illumination on a continuous-current circuit by half an ampere, or by 100 volts, will be brought to full illumination by these same quantities of current and voltage on an alternating-current circuit, no matter what the shape of wave, assuming, of course, as experiment shows we may, that the "skin effective" and the induction in the lamp filament are negligible. If, on the other hand, alternating current apparatus were calibrated in "mean" values, the voltage or current necessary to supply lamps at normal candle-power would not only differ from the corresponding continuous-current values, but would also depend upon the shape of the alternating waves

ALTERNATE-CURRENT TRANSFORMER DESIGN.

BY R. W. WEEKES, WHIT.SCH., A.M.I.C.E.

(Continued from page 622, Vol. XI.)

Third Design.—In this, the last transformer to be designed, we will make the mean lengths of the copper and iron circuits nearly equal. The first design had a short copper circuit and a long iron core; then in the second these relative proportions were reversed and the iron circuit was short. Now, the mean length of the turns in the copper circuits and the length of the path of the magnetic lines will be, roughly, the arithmetical means of the respective values in the two previous designs. This gives a transformer of the type used by Ferranti, in which a rectangular core of iron is surrounded by rectangular formers containing the copper conductors.

Assuming the core to be 9in. long by 3in. broad, and the length of winding formers to be about 9½in., we can roughly estimate the weight of iron in the transformer, Figs. 19 and 20. The cross-section of the iron equals 85 per cent. of 27 square inches = 23 square inches, or 148 square centimetres. The length of the iron circuit cannot be accurately determined till the winding has been fixed, but will be, roughly, 28in., so that the volume of the iron = 23 × 28 = 642 cubic inches and weighs 180lb. The iron loss allowed is 150 watts, so that the loss per pound = $\frac{150}{180}$ = ·835 watt. The curve of total iron losses, Fig. 4, shows that this

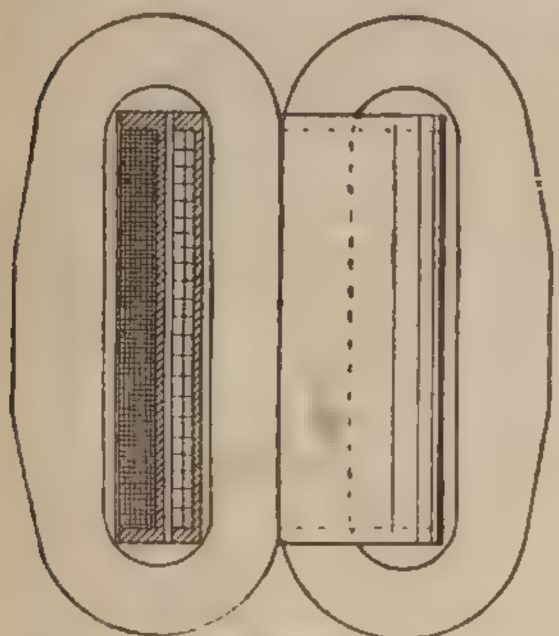

FIG. 19.

corresponds to an induction of about 3,500 lines per square centimetre. The core area being 148 square centimetres, hence the total flux equals 148 × 3,500 C.G.S. lines, ∴ F = 518,000.

Designing the secondary winding first from (1)

$$e_2 = 4{\cdot}45\ F\,\tau_2\,n\,10^{-8},$$

and allowing 102 volts to make up for the drop due to copper loss at full load, we get

$$102 = 4{\cdot}45 \times 518{,}000 \times \tau_2 \times 100 \times 10^{-8};$$

$$\tau_2 = \frac{102}{4{\cdot}45 \times {\cdot}518} = 44{\cdot}2 \text{ turns.}$$

We must have an even number of turns, as two layers will be the most convenient method of arranging the secondary strip—44 being the nearest even number, will do well for the number of turns in the secondary. The primary turns can now be calculated from

$$\tau_1 = \frac{\tau_2 \times 2{,}000}{102} = \frac{44 \times 2{,}000}{102},$$

$$= 865.$$

In this type of transformer the coils are usually wound separate formers and slipped on individually. The question of which should be nearer the core has been often discussed, and the balance of advantage appears to lie in placing the secondary next to the iron, as then the high volt winding is farther from the iron, and less likely to leak to earth. Also, the thick wire of the secondary is wound on a smaller former, and is hence more stable. The question of eddy currents in the copper due to leakage of magnetic lines from the core out through the copper has been urged as a reason for putting the thick wire outside. With certain strained assumptions as to leakage and copper weight, this appears to be a valid reason but for the fact that the eddy-current losses in the copper are so small as to be negligible in most transformers. Assuming the leakage to take place radially from the core, the induction and hence the eddy-current loss per unit volume of copper, is greater near the core. But the volume of copper required increases more rapidly than the perimeter of the winding if a constant full load drop is allowed, and so the increase of volume varies almost as the square of the perimeter. This increase in volume or weight of conductor balances the decrease in the density of the leakage field, and keeps the Foucault loss constant. Hence there is no disadvantage from leakage caused by winding the thick wire near the core. Placing, therefore, the secondary inside, it is necessary to design it first, as its thickness will affect the perimeter of the primary.

The clearances between the insulating cylinder and the iron must be slightly more than in the previous design,

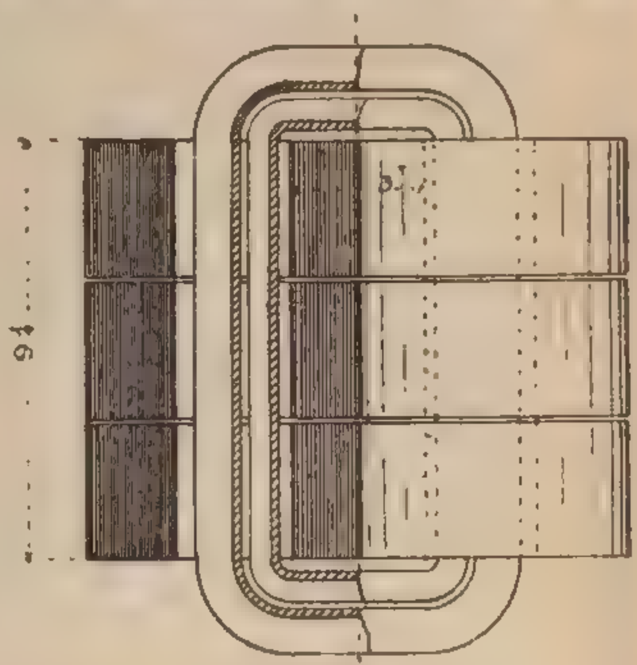

FIG. 20.

owing to the method of core construction used. Fig. 20 shows the general outline of the coils, and from it the mean perimeter of the secondary equals 2·37ft. The total length of the insulating cylinder being 9½in., we shall get about 8½in. for winding space. The section of the tape to be used is got from (3)

$$s = \frac{i\,\tau_2\,\pi_2\,9{\cdot}2}{\theta}\,10^{-6};$$

and $i = 60$ $\pi_2 = 2{\cdot}37\text{ft.}$

$\tau_2 = 44$ $\theta = 1.$

$$\therefore\ s = 60 \times 44 \times 2{\cdot}37 \times 9{\cdot}2 \times 10^{-6};$$

$$= {\cdot}0572 \text{ square inch.}$$

The tape had best be wound in two layers of 22 turns each, so that the insulated tape should measure $\frac{8{\cdot}5\text{in.}}{22}$, say, ·385in., in order that 22 turns may be wound in 8·5in. Uninsulated the copper would be about ·350in. broad, and to give the section must be ·165in. thick. Tape (·350in. × ·165in.) will therefore be used, and the two layers will give a total depth of winding of ·4in.

Calculating the resistance as in previous designs for the exact section of the tape, ·0577 square inch, we get from

(3) that $r_2 = \cdot 0166$, which, with 60 amperes, gives just under the one volt drop allowed.

The weight of copper from

$$g = S\,\tau\,\pi \times 3\cdot 85,$$

by substituting the proper value for the symbols becomes

$$g = \cdot 0577 \times 44 \times 2\cdot 73 \times 3\cdot 85\,;$$
$$= 23\text{lb.}$$

The clearance between the outside of this secondary winding and the primary cylinder must be sufficient to allow the latter to be slipped on. The space left is by no means wasted, as it provides ventilation to the wires in the centre of the coil. In fact, with a transformer so placed that these cylinders are vertical, the chimney action in these air spaces between the windings is most useful in cooling the wires. This space and the necessary thickness of cylinder and wire raises the mean perimeter of the primary wire to about 2·87ft. This is the only remaining unknown quantity in the equation for the diameter of the wire :

$$d = \sqrt{\frac{i_1\,\tau_1\,\pi_1\,11\cdot 75}{\theta}}\,10^{-3},$$

the other values being as follows :

$$i = 3\,;\ \tau_1 = 865\,;\ \pi = 2\cdot 87\,;\ \theta = 20\,;$$

$$\therefore\ d = \sqrt{\frac{3 \times 865 \times 2\cdot 87 \times 11\cdot 75}{20}}\,10^{-3}$$
$$= \cdot 066\text{in.}$$

So 66-mil wire will give the 1 per cent. loss, and it can be wound in eight complete layers of 100 turns and one layer of 65 turns. In between each layer it will be necessary to place a sheet of insulating material, as there will be a difference of potential of about 470 volts between adjacent wires in different layers at the ends of the coils. This extra insulation will increase the depth of the winding to about ·85in. The resistance of the wire from (4) is

$$r = \frac{\tau_1\,\pi_1\,11\cdot 75}{d^2}\,10^{-3}$$

$$= \frac{865 \times 2\cdot 87 \times 11\cdot 75}{\cdot 066 \times \cdot 066}\,10^{-3}$$

$$= 6\cdot 68 \text{ ohms.}$$

The weight of conductor, from the formula following the above, works out to 32·7lb. These calculations complete the design of the copper circuits.

With the Ferranti system of building up the core and yoke, the question of winding space does not affect the calculations so much. It is necessary first to design the coils to suit the core area allowed, and then to get out the length of plates required to encircle these coils with ample clearance. Leaving the actual details of construction till later, we can, from Fig. 19, get the mean length of the iron circuit, which is 28·5in., or 72·7 centimetres. The cross-section of iron was 23 square inches, so that the exact volume will be 656 cubic inches, weighing 183lb. The total field, F, required when $\tau_2 = 44$ will be 520,000 C.G.S. lines, so that $\mathfrak{B} = \frac{520{,}000}{148} = 3{,}520$. The loss per pound in watts at this induction for the iron assumed by curve, Fig. 4, is ·827, so that the total iron loss $= \cdot 827 \times 183 = 151$ watts. The watt current, i_H, required to give this power at 2,000 volts $= \frac{151}{2{,}000} = \cdot 0756$ ampere.

The next step is to determine the μ current from $i_\mu = \frac{\mathfrak{B}\,l}{\mu\,\tau_1\,1\cdot 76}$.

In this transformer $\mathfrak{B} = 3{,}520$;
$l = 72\cdot 7$ centimetres;
$\mu = 1{,}950$ from curve, Fig. 5;
$\tau_1 = 865$;

$$\therefore\ i_\mu = \frac{3{,}520 \times 72\cdot 7}{1{,}950 \times 865 \times 1\cdot 76}\,;$$
$$= \cdot 0864 \text{ ampere.}$$

Now i, the magnetising or no-load current,

$$= \sqrt{i_H^2 + i_\mu^2},$$
$$= \sqrt{\cdot 0756^2 + \cdot 0864^2},$$
$$= \cdot 115 \text{ ampere,}$$

which is 3·83 per cent. of the full-load primary current.

Collecting all the figures into a list.

Six-Kilowatt Transformer—Third Design.—Ratio of transformation, 2,000/100 volts; $\frown\!\smile = 100$.

Core, 9in. × 3in.; area of cross-section of iron, 148 square centimetres.

$\mathfrak{B} = 3{,}520$; F = 520,000; $l = 72\cdot 7$cm.

Primary: $\tau_1 = 865$; $\pi = 2\cdot 87$ft.

Wire, 66 mils diameter, wound in eight layers of 100 turns per layer and one layer of 65 turns per layer.

$r = 6\cdot 68$ ohms, hot; loss = 1 per cent.; weight, 32·7lb.

Secondary: $\tau = 44$; $\pi = 2\cdot 73$.

Conductor used, tape (·350in. × ·165in.), wound in two layers of 22 turns each.

$r = \cdot 0166$ ohm, hot; loss, 1 per cent.; weight, 23lb.

Losses—Iron	151 watts ...	2·51 per cent.
Copper, primary...	60 „ ...	1·0 „
Copper, secondary	60 „ ...	1·0 „
	271 watts	4·51 per cent.

The efficiency at full load being

$$\frac{6{,}000}{6{,}271} = 95\cdot 7 \text{ per cent.}$$

Magnetising current = 3·83 per cent., so that the load factor, or ratio of true watts to apparent watts on open circuit, equals ·657.

The weight of iron =	183lb. at 4d. per lb. =	61s.
„ copper =	55·7lb. at 10d. per lb. =	46·5s.
Total............	238·7lb.	107·5s.

Which gives 39·8lb. and 18s. per kilowatt output.

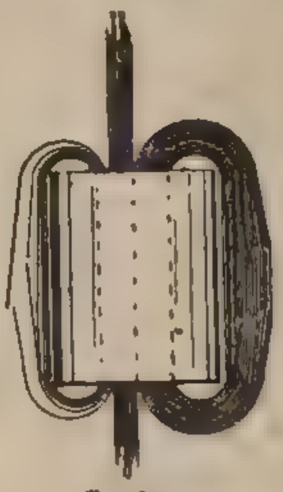

Fig. 21.

The ratio of weight of copper to weight of iron equals $\frac{55\cdot 7}{183} = \cdot 304$.

The effective cooling surface of this transformer is difficult to estimate correctly, and comparisons made on the basis of the watts wasted per square inch total external surface will not afford a true idea of the heating limits. This is caused by the number of ventilation spaces running right through both the copper and iron circuits, which by their cooling effects greatly assist the external surfaces. The surface which is exposed externally amounts to only 750 square inches, and hence the watts per square inch work out to $\frac{271}{750} = \cdot 362$ at full load, and to $\frac{151}{750} = \cdot 201$ at no load.

The method of construction of the iron circuit is explained in Fig. 21. In this transformer, as designed, the iron

used consists of strips 3in. broad, arranged in three parallel bands, Fig. 20. This is done to facilitate the bending of the plates, and also to give increased ventilation through the iron. Also, it tends to reduce eddy currents in the iron if any appreciable magnetic leakage takes place out from the core through the broad plates. These strips of iron are cut to various lengths, as shown in Fig. 21, and laid out perfectly straight with alternate plates projecting each way. Then the formers containing the conductors can be slipped on over this rectangle of iron and secured in the centre of it. The next step is to bend the plates individually into their final positions. The reason of having them with alternate intervals at the ends is to secure that they break joint at the centre of the yoke. This keeps the magnetic resistance low, as explained in other designs. The weight and cost of this transformer will be found to compare favourably with those of the two previous designs, but it will not be correct to say from this that the type is the best. Until the best design of each type has been definitely fixed it is misleading to institute comparisons. So in this case the effects of less iron and more copper should be carefully investigated.

(To be continued.)

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC.MEM.INST. ELECTRICAL ENGINEERS.

ARC LIGHTING.

(Continued from page 623, Vol. XI.)

The direction of path of a ray of light emanating from a source is defined by its "angle of incidence." The angle of incidence signifies the angle that the ray in question makes with a vertical line dropping down from the centre of the source of light. The top diagram in Fig. 25 illustrates rays having angles of incidence of 30deg., 45deg., 60deg., 70deg., and 80deg., the horizontal line being, of course, a right angle, or 90deg. They also show at what points they touch the ground-line for various heights of the lamp. A, B, and C denote three different ground-lines, thus giving the arc three different heights, in the ratio of 1, 2, 3. The innermost ray of the belt of maximum light previously mentioned has evidently an angle of incidence of 30deg., because 60deg. below the horizontal is the same as 30deg. out of the vertical. Similarly, the outermost ray has an angle of incidence of 60deg. These two angles of incidence are drawn in thick lines to mark the borders of the belt, and the base which lies between the borders is shaded for the three ground-lines, A, B, C. It will be noticed that the ray having an angle of 80deg. touches the ground-line some distance from the lamp; in addition to this, the light given at that angle is much below the maximum, so that the illuminating power is only feeble: therefore it is not worth while receiving rays that have an angle of incidence greater than 80deg.

An arc lamp forms an elevated centre of the illuminated circle, and it is interesting to examine into the relations between heights and distances, etc. We will assume that the arc is at such a height that the farthest point to be illuminated is reached by a ray having an angle of incidence of 60deg.

Let the height of the arc above the ground be, say, 10ft., as shown by the line, $b\ c$. Then, since the farthest point illuminated is where the ray of 60deg. reaches the ground, hence the horizontal distance, c P, will represent the radius of the illuminated circle. This distance, c P, we will call the "radius distance," to distinguish it from the angular distance, b P. Knowing the angle and the height, it is easy to find the radius distance, which is obtained from the formula :

Radius distance = height × tan A ;
also, Height = radius distance × cotan A,

where tan A and cotan A represent the tangent and cotangent of the angle of incidence of the ray. In the present case the angle of incidence is 60deg., and the values of tan 60deg. and cotan 60deg. are respectively 1·73 and ·578. *Inserting these values, we have*

Radius distance = height × 1·73,
and Height = radius distance × ·578.

So if the height, $b\ c$, be 10ft., then the radius distance, c P, will be 17·3. The length of the path of the ray can also easily be found when the height and the angle is known, since it equals the height divided by the cosine of the angle of incidence. Now cos 60deg. is ·5 ; hence 10 ÷ ·5 = 20, so that the path of the ray denoted by b P = 20. It may be put down as a rough rule that an arc will illuminate well for a radius distance equal to double its height, because no rays beyond 64deg. are then required.

Rays having an angle of 80deg. will illuminate at a radius distance equal to about five and three-quarters the height of the arc from the ground. For a ray at a fixed angle, its radius distance and its length of path will be directly proportional to the height of the lamp, but if the candle-power remains the same, the illuminating power of the ray where it reaches the ground will diminish very considerably as the height of the lamp increases. In the lower diagram of Fig. 25, when the height, $b\ c$, is 10ft., the radius distance, c P, is 17·3ft. for a ray of 60deg. as shown, and the length of the path of the ray, b P, is 20ft. Suppose at the point, P, where the ray falls on the ground that the illuminating power or intensity of the ray is equal to 10 c.p., allowing that the light given off the arc

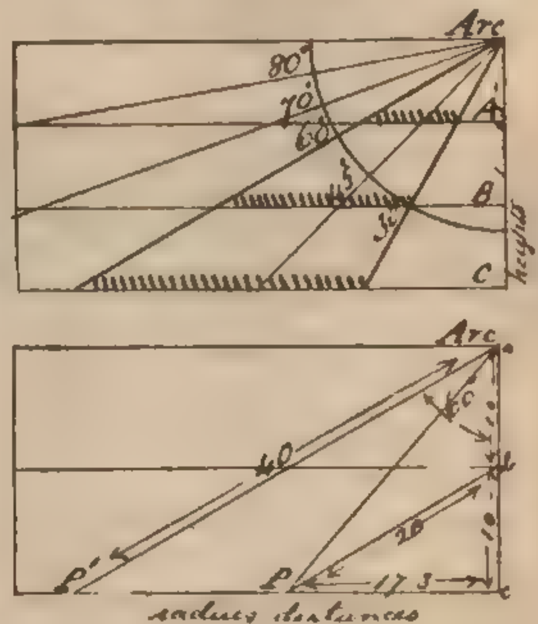

FIG. 25.

at this angle is three-quarters of the maximum ; now double the height of the lamp, making it 20ft., the length of the path of the ray will now be doubled and the new point, P', where it reaches the ground will be 40ft. away from the arc. The intensity of light varies inversely as the square of the distance from the source of light, and since the distance is doubled it follows that the intensity will be only one-fourth, and so the candle-power at P' will be 2·5. From this it is seen that the candle-power of a ray at a fixed angle varies inversely as the square of the height of the lamp at the point where it touches the ground. Now, instead of keeping the angle of the ray constant, keep the same point, P, under consideration when the height is varied ; then, when the height of the lamp is doubled, the angle of the ray falling on the same point, P, will be much smaller. To find how the intensity alters at the point, P, we must first obtain the lengths of the two paths, P b and P a. P b = 20, and P a = $a\ c$ ÷ cos P $a\ c$. We have now to find out what the new angle P $a\ c$ is. To do this, we already know that the radius distance ÷ height = tan of the angle of incidence, therefore P c ÷ $a\ c$ = tan P $a\ c$; that is, 17·3 ÷ 20 = ·865 = tan 41deg., nearly. Having now obtained our new angle, all that is wanted is the length of the path P a, and, as given above, P a = $a\ c$ ÷ cos 41deg. = 20 ÷ ·754 = 26·5 ; so that the path P b, representing the old ray of 60deg., is 20ft. long, while the path, P a, of the new ray of 41deg. is 26·5ft. long. The intensity varies inversely as the square

of the distance, hence the candle-power at P, when the height of the lamp is 20ft., will be $10 \times 20^2 \div (26 \cdot 5)^2 = 4{,}000 \div 702 \cdot 25 = 5 \cdot 7$ about.

Finally, we must make a correction, because the light given by a ray of 41deg. is of greater intensity than what is given by a ray of 60deg., other things benig equal. At 60deg the light was assumed to be three-quarters of the maximum, and at 41deg the light may be taken to be almost at the maximum, so $5 \cdot 7 \times 4 \div 3 = 22 \cdot 8 \div 3 = 7 \cdot 6$ = candle-power at the point P, when the arc is at *a*, or 20ft. high.

Consumption of Carbon.—It will be found in practice that the positive or upper carbon burns away at twice the rate at which the negative or lower carbon does. The proportions are not exactly 2 : 1 ; in different lamps and with different kinds of carbons the proportion varies slightly, but, as a rule, they will all come pretty close to the above ratio, and when trimming, the lamp trimmer always allows double the length of positive to the length of negative. The writer obtained the following rate of consumption of carbon, being the average of a number of tests made on a Brockie Pell "full" arc lamp:

Positive carbon, $\frac{5}{6}$, or ·833in. per hour.
Negative „ $\frac{3}{8}$, or ·375in. „
Current being 10 amperes.
Pressure being 40 volts.
Energy consumed by lamp being 400 watts.
Diameter of carbons being 13mm.

With a full arc lamp, or one taking 10 amperes, the best size of carbons to use is 13mm., or $\frac{1}{2}$in., in diameter. With a half arc, or one taking six to seven amperes, carbons of 11mm., or $\frac{7}{16}$in., in diameter, should be used ; for a small lamp taking only five amperes, say, about 9mm. is suitable, whilst for a very powerful lamp, such as a searchlight of 25,000 c.p., and taking a current of probably 50 amperes, the size would be about 24mm., or close on 1in., in diameter. The rate of consumption of these larger-sized carbons is less than the smaller sized ones, the burning being slower as the carbons increase in thickness. Carbons smaller than 9mm. for five amperes, and those larger than 40mm. for, say, 130 amperes, do not burn well, it being very difficult to obtain a well-formed crater, consequently the light is unsteady. It is the custom now in the best kind made to insert a central soft core in the positive carbon ; these are called cored carbons. They are naturally more expensive than the other solid kind, but they give a better, softer, and steadier light. The soft core tends to keep the crater in the centre of the carbon, and promotes a more regular burning ; the light also is purer and whiter. There is a great art in manufacturing electric light carbons, each maker having some little secret of his own in compounding the ingredients that form the paste. Gas-retort carbon, or gas coke, as it is called, is crushed into a fine powder and then mixed with several things, as pitch, oils, etc.; the compound is passed through a number of processes, then subjected to great pressure and finally baked in the furnace. Provided a good lamp be employed, the character of the carbon soon proves itself ; a bad and impure specimen burns irregularly, splutters, and is continually breaking its arc, and so causes the light to fluctuate up and down, and, above all, the light given off is often a greenish-red or a purple colour, making those on whom it falls have a very bilious look. A good carbon, however, acts very differently : it burns steadily, with little waste, the light is pure, full and white, and perfectly steady.

Coated or coppered carbons are those which are coated over with a thin deposit of copper, to conduct the current better. A single-carbon lamp means one that has only one pair of carbons, and a double-carbon lamp one that has two pair, so that when the first pair is burnt out, the lamp changes over on to the second pair. The usual length that carbons are cut is about 16in for positive, and 8in. for negative, so that the single lamp will burn for 16 hours and the double lamp for 32 hours. The consumption will not reach 1in. per hour for the positive, as the carbon stumps will testify ; in any case the carbons should never be allowed to burn down to less than 1in. away from the holders, otherwise the holders will get heated and burnt. The depth of holders is about $\frac{1}{2}$in., so the stumps should not be less than $1\frac{1}{2}$in. long when taken out.

(To be continued.)

THE TRAMWAYS INSTITUTE OF GREAT BRITAIN AND IRELAND.

The annual general meeting of this institute was held on Thursday of last week at the Holborn Restaurant, W.C., Mr. W. J. Carruthers-Wain occupying the chair.

On the proposal of Mr. J. EBB-SMITH, seconded by Mr A. P. SMITH, Mr. Carruthers-Wain was unanimously re-elected president for the ensuing year. The vice-presidents (Mr. J. Ebb-Smith, Mr. J. W. Turton, and Mr. A. P. Smith), on the motion of the CHAIRMAN, seconded by Mr. STANSFIELD, were re-elected. Mr. Whittaker, Mr. Waugh (of Bradford), Mr. S. J. Wild, and Mr. William Mason were elected executive committee on the proposition of Mr. S. L. TOMKINS, seconded by Mr. FORBES. Mr. FORBES then moved, and Mr. PAGE seconded, the re-election of Mr. Chris. James and Mr. W. Stansfield as honorary auditors.

The SECRETARY (Mr. J. G. B. Elliot) then read the report of the council for the year 1892-93. The report showed that there were now 32 companies, 47 delegates, and 164 associates belonging to the institute. These figures showed an increase, as compared with the previous year, of one company, 11 delegates, and four associates. One company had resigned owing to the line having been purchased by the local authority, and six associates had ceased to belong to the institute owing to death and resignation. Since the last meeting two gatherings had been held in the provinces—namely, at Birmingham in December, and at Liverpool in April. At the Birmingham meeting the members inspected the Walsall electric tramway, and the electric railway at the Liverpool assembly. The council was gratified at the success which had attended their efforts to introduce to the notice of members all the newest developments in the application of modern science to traction, and the affording to them of opportunities for viewing inventions having for their object the benefit of the tramways. The matters discussed at previous meetings included, amongst others, the consideration of permanent way construction, electric traction by overhead wires, and the amendment of the Tramways Act of 1870, claims of telephone companies and opposition to electrically-worked tramways, new car-starting and emergency brakes, and a new gas-motor car. It had been impossible to proceed with the amendment of the Tramways Act of 1870, which, by the admission of a past-President of the Board of Trade, required amending. That question concerned the convenience and comfort of 600 million passengers, to say nothing of the reasonable wishes of the large body of the investing public, whose money had supplied the facility for cheap locomotion to that enormous number of people, and whose return on their capital was in most cases extremely inadequate, whilst in many instances no return whatever could be earned by the capital employed. It was impossible for the same reason mentioned in previous years to obtain capital for tramway purposes, and new lines and desirable extensions of old lines demanded for the public convenience could not be built. The council felt that the time had come when it was the plain duty of tramway companies to bring pressure to bear on the Legislature, in the first instance by urging their shareholders to become associates of the institute, thereby greatly increasing its power and influences and resources ; and in the second place, to bring personal influence to bear upon the member for Parliament who represented the particular district in which each shareholder resided, as well as to sign a petition to Parliament praying for the appointment of a select committee to enquire into the operation of the Tramways Act, 1870, with a view to its amendment in the light of the experience gained in the past 23 years. The most important events of the year, from a traction point of view, had been the opening of the

South Staffordshire electric tramway, the Liverpool overhead electric railway, the cable tramway at Matlock, and the cable line from Kennington to Brixton. The chief event of the year had, however, been the decision of Sir Frederick Bramwell, the arbitrator appointed by the Board of Trade to decide on the price to be paid for a portion of the lines of the London Street Tramways by the London County Council. It was understood that while the price was far more than the County Council expected to pay, it was much less than satisfied the company. Any further proceedings in this case would be watched with interest. As an illustration of the justice of the views held by the Tramways Institute on the action of the local authorities and the purchase clause of the Act of 1870, it was mentioned that in the case of the London, Deptford, and Greenwich Tramways Company, who voluntarily offered to sell their lines to the London County Council at a price to be mutually agreed upon, the latter declined to entertain the suggestion.

Mr. W. J. CARRUTHERS WAIN, in moving the adoption of the report, and after referring to statistics of tramway work, spoke as follows about electric traction: "They found that whereas the application of modern science in the United Kingdom had resulted in the construction of only 33 miles of electric tramways during the 10 years since it was first commenced with the Portrush and Giant's Causeway Railway, opened in 1883, the idea of electric traction did not really take hold of the American public until 1887; and since that time the progress had been so marked, and the convenience of the additional facilities given had been so marked, that last year the number of electric tramways in the United States was 436, with 3,532 miles of track, and 5,851 cars carrying 250,000,000 passengers annually. That only showed what capital could do, what freedom from arbitrary restrictions imposed by local authorities could do, and what the study of the public convenience would result in for the shareholders in those companies. He thought if anyone had an opportunity of reading the remarks made by Mr. Reckenzaun during the discussion on Dr. Hopkinson's paper before the Institution of Civil Engineers, they would repeat the reasons why in America that could be done and not in this country. In any case, the public were the sufferers and the tramway companies the losers."

Mr. WM. MASON, in seconding the motion, observed that the institute had been of great benefit to tramways belonging to the institute, and to those who were not connected with it.

Some discussion ensued. It was mentioned that there were 80 companies in the United Kingdom, and that only 32 were affiliated to the institute; in the metropolis there was only one in seven connected with it. It was urged that the council should endeavour officially and as effectually as possible to induce those companies outstanding to join the institute. It was also suggested that the council should on the occasion of Board of Trade inspections of lines and rolling-stock, and especially steam locomotives, give some distinct advantage to the companies so as to deal with the changing requisitions of the Board of Trade, and which put the companies to considerable expense.

Mr. CARRUTHERS-WAIN said, in reply, that the council would be glad to accept the proposal, and that by so doing it would bring in other companies. The quarterly meetings would be held as usual. An invitation had been received for the institution to visit the Isle of Man in October to be present at the opening of the electric tramway from Douglas to Laxey, but he did not know whether the line would then be in operation.

A paper was down on the agenda, on "Electric Traction," by Mr. L. EPSTEIN, who, however, made his remarks in an address on

RECENT RESULTS OF ACCUMULATOR TRACTION.

When he read a paper before the institute a year ago, he then pointed out to the best of his belief that it could be proved in actual working that accumulators would fulfil all conditions necessary to make traction by their means a success. At that time certain doubts were expressed, but the author was now in a position to submit figures which he thought would prove that the hopes held out 12 months ago had been realised by the use of the Epstein cells on some of the cars of the Birmingham Central Tramways Company. There were six cars in regular operation in that town, and sometimes seven. There were 12 sets of accumulators in use. The first were supplied in December, 1892, and they had had sometimes to contend with difficult conditions of the road; several times in January and February they had to deal with falls of snow, and measurements taken disclosed the fact that the energy required to propel a car up a gradient of 1 in 25 rose to 33 i.h.p. The 12 sets, which represented 1,200 cells, or 10,000 plates, were working satisfactorily in Birmingham at the present moment, and they were the identical cells that had done work since December and during the severe conditions of the road already mentioned. As far as repairs were concerned, not a single plate had been changed or repaired; putting that into mileage, it meant that the sets in use had done about 6,000 miles, the total mileage being about 80,000. He had information to the effect that the irregularities in the traffic from any cause were very slight, and compared favourably with those on the lines operated by other means. The author then came to consider the relative merits of the accumulator system and the direct-current method. Taking first the cost of installation, he observed that it had been elicited that the cost of effectually equipping one mile of track on the overhead system amounted to about £4,000 a mile, and that of the conduit system to about £6,000 a mile. Assuming a line six miles long, that would come to £24,000 with the former and £36,000 with the latter system, apart from other electrical equipment. They knew that the equipment of a car with accumulators cost £500, apart from the other electrical equipment which was common to both. Taking a five minutes' service—which was a pretty good one—they found that on a line with double track 24 cars were necessary to maintain that service. The 24 cars would cost £12,000 as compared with £24,000 with the trolley system, and £36,000 for the conduit method. Coming to consider the cost of working, that was more economical at the station than the working of stations where provision had to be made for varying demands. The main points, however, were: What was the supervision that accumulators required, what were the repairs, and what was the cost of keeping them in working order? In other words, what was the cost of running them? On these points, he would simply record facts. As far as supervision in Birmingham was concerned, he was only aware that of the 12 sets that had been in operation since December, six sets had been cleared out once so as to get rid of the mud, and that clearing was the only expenses incurred in the supervision of accumulators; in other words, the supervision was practically nil, and also the cost of supervision. With regard to repairs, he would repeat what he had said at the commencement of his remarks—that it had not been necessary to repair a single plate out of the 10,000. As to the cost of renewals, his company was under a contract with the Birmingham Central Tramways Company to renew the accumulators, or such parts as required renewal, at a certain fixed rate per car mile run. In this case the rate was 1½d. per car mile, and each set of accumulators had made 6,000 car miles, and considerably less than that mileage was sufficient to reimburse his company for the cost of renewals.

In the course of discussion, Mr. CARRUTHERS-WAIN said that he was not an advocate of any system. He mentioned that the working of the Epstein accumulators during the past six months had enabled the lines to be operated with great regularity. With regard to the financial aspect of the question, that was not a matter with which he could deal. He only knew what the arrangements with Mr. Epstein were or were likely to be, and he would wait until the end of the year, which terminated on the following day, and then find out what the cost of accumulator traction had been on the Birmingham line during the past 12 months. The figures given by Mr. Epstein had been supplied by the tramway company.

Mr. FELL asked as to the cost of equipping a tramway, including the rolling-stock, motors, batteries, and plant at the depôt, but leaving out of consideration the depôt and

the tram line. The tramways had the lines, and it was most important to tramway men to know the cost of installation.

Mr. SCOTT RUSSELL said that the Brush Company would undertake the responsibility for the equipment of a line, and they had calculated that to extinguish the extra capital outlay involved in the fitting up of an existing line with electric traction, a sinking fund of 1½d. per car mile was necessary. That was one of the serious considerations they had had to deal with in this country—that the existing horses and cars had to be put aside, and before any saving could be shown a saving must be manifested over and above a sinking fund of 1½d. per car mile. Unless it could be demonstrated that something like 2d. was to be saved, it was scarcely worth while to equip a line electrically, except for one consideration. All mechanical powers allowed of traffic being dealt with as it arose; with mechanical power a much larger car could be run at practically the same cost per car mile.

Mr. EPSTEIN had worked out on a different basis to that of the previous speaker, but in order to show the actual amount, no matter how it was to be refunded, he found that it was as near as possible £1,000 per car.

Mr. FELL asked for an approximate estimate of equipping, say, 10, 20, 50, or 100 cars. That would bring in all tramway companies now experiencing any difficulties.

Mr. EPSTEIN replied that it would be about £1,000 per car, and he stated that he would undertake to maintain accumulators at 1d. per car mile.

A paper was then read by Mr. CONRADI, C.E., on the "Cleaning of Permanent Way."

The next paper, presented by Mr. H. U. WOLLASTON, dealt with the

LIGHTING OF OMNIBUSES AND TRAMCARS.

The author described the system of compressed oil-gas lighting introduced by Messrs. Pope and Son, Limited, of Slough, on railways, tramways, and for omnibuses. The arrangement consists in the carrying on the cars of gas-cylinders, which are charged with gas from stationary high-pressure holders. The cost is given at 15s. per thousand for the gas placed on the cars, being one-tenth of a penny per lamp per hour.

The next paper, of which we give an abstract, was by Mr. E. FREUND on

LIGHTING OMNIBUSES BY ELECTRICITY.

The apparatus consists of a Bristöl battery weighing about 8lb., and a lamp of very shallow design, which can be fixed with three screws to the roof of the 'bus. The battery contains six cells, connected for power—viz., for 12 volts. The cells are made of ebonite, which is the only material which permanently resists the sharp tooth of sulphuric acid, and which is at the same time the best insulating material known. Each cell contains a positive and a negative electrode, well distanced from each other, and submerged in diluted sulphuric acid. The positive plates consist mainly of peroxide of lead, the negative plates of spongy metallic lead, and both contain a thin strip of lead, which projects out of the plate, and which serve to make the connections. These plates are manufactured by the Bristol Electric Safety Lamp Works under Bristol patents, and differ greatly from all other plates by having no metallic frames. Such frames do not take part in the electro-chemical process of storing and discharging electricity, and as they very often weigh more than the active material, their absence means a great gain in point of weight.

Being quite homogeneous, the Bristöl plates are less affected by change of temperature or shock than any other plates, and they will permanently stand high rates of charging and discharging. Looking at this from the point of view of omnibus-lighting, where, say, a five-candle lamp is wanted for six hours on an average, a Bristol A A battery, weighing 8lb., can discharge fast enough to maintain this light, while 15lb. or 20lb. would have to be carried were another type of battery chosen. Compactness and small weight are not only convenient, but they influence the price of maintenance very favourably. If several hundred batteries have to be handled in the shortest possible time, 10lb. extra apiece will tell on the wages' bill. Being bulkier, heavy batteries will require more space on the charging tables, the charging office will have to be larger, and more attendants will be required for replenishing the liquid as well as on account of the larger table space. The same increase will take place with all expenses connected with the collecting and repairing of the batteries.

The ebonite cells are closed with a splash and acid proof cover, which contains a small hole in the middle through which the harmless gases which develop principally during the charging may escape. The metal terminals of the plates pass through these covers, and are joined above in the proper way and connected to the battery terminals. These consist of flat strips of brass fixed to the front of a wooden box, into which the ebonite cells are cemented. They are about 1½in. apart from each other, and correspond with a pair of strong metal springs, which are fixed to the inside of a case provided under the seat of the omnibus. Two well insulated wires connect the contact springs of the case with the electric lamp. They are carried up behind the upholstering, along the pillars and principals of the roof, and are hardly noticeable and quite out of the way.

The lamp, which is another remarkable feature of the Bristöl system, consists of a wooden base of 5in. diameter, which carries a metal frame and a screwed bezel for the hollow crystal lense. The incandescent lamps are of Ediswan's fairy type, and are supported by elastic hooks of hard-drawn wire which cushion the constant vibrations effectively, and cause the light to be perfectly steady. From the experience gained with this method it can be said that incandescent lamps last under these conditions from three to four months. . . .

The charging takes between three and seven hours, according to the duration of the lighting, and, except the replenishing of the diluted acid, which a boy does every fortnight, no other electrical work is wanted. The expense for current is a very small item as long as the batteries are regularly used and returned. Repairs also do not amount to much so far as electrical wear and tear is concerned. The only difficulties encountered were caused by guards which short-circuited the batteries by putting them face to face, and partly by carelessness in returning the batteries without even strapping them. The first-named stumbling block was removed by putting protectors on to the batteries which make their terminals inaccessible so far as accidents are concerned. The second difficulty can easily be overcome by the use of boxes for the collection of the batteries.

An estimate for lighting 200 omnibuses could, for the first year, be made up in the following way:

Outfit, £3. 10s. per 'bus	£700	0	0
Twenty spare batteries at £2. 10s. each	50	0	0
Fitting up of charging station	25	0	0
First cost	£775	0	0
Electric current per annum	£50	0	0
Wages	150	0	0
650 incandescent lamps at 1s. 6d. each	48	15	0
Repairs	£50 to 100	0	0
Rent for charging station	10	0	0
Depreciation, 15 per cent.	116	5	0
Maintenance	£475	0	0

or £2. 7s. 6d. per 'bus per year, as a maximum for the first year.

Nothing is allowed in this estimate for careless or malicious treatment, or for management. These items depend greatly on circumstances, which have to be considered in every case. The item for repairs, however, include an ample allowance for accidents on the road and mistakes of the attendant.

The Secretary then read a paper by Mr. SHARP, on "The Connelly Motor."

The last paper read was by Mr. J. M. GROB, on "A New Petroleum-Motor."

Aberdeen.—The sanction of the Secretary for Scotland has been received to the loan of £20,000, to be raised by the Aberdeen Town Council for the erection of the works for the electric lighting.

THE

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GAS POWER.

This is the title of a paper by Mr. J. Emerson Dowson, read at the late meeting of the Gas Institute. Mr. Dowson, as all men know, is the great advocate of the gas-engine and ——. There is much in this and ——. But, advocate of the gas-engine as he is, we claim him to be also one of the best advocates of electric lighting. Mr. Dowson assumes the correctness of the statements made by Dr. Hopkinson, the late Dr. Siemens, and Mr. Gisbert Kapp, to the effect that "when ordinary town gas is burnt in a gas-engine to drive a dynamo, much more light is produced electrically than can be produced by burning the same quantity of gas in burners in the usual way." We have heard this statement denied by those who ought to know better. They argue that it cannot be, because of losses in engine, dynamo, and mains. They forget, or they do not know, that consuming ordinary town gas for light purposes is not the same as consuming it for heat purposes. On a blustering Saturday or any other night the flaring gas jets in the shop windows are almost blown out, so to speak, as far as light is concerned, but the heat generated by the jets is far greater than under ordinary conditions. A Bunsen burner consumes the gas to give heat, but not much light. Therefore, it is somewhat easy to see that by consuming the gas for heat in an engine may be far more economical, even after allowing for all losses, than burning it for light. Mr. Dowson, as we say, admits the correctness of this view, but goes further, and says that while it is economical to use town gas for burning in engines, it is still more economical to use gas prepared specially to be consumed for heating and not for lighting. For some years he has held forth on this thesis—the electric light is better than gas light; it is bound in the long run to take first place; its production requires the use of prime motors—then why not, you who have investments in gasworks, gird up your loins, take the bull by the horns, provide cheap gas for engines, then utilise your works, and provide what the public most assuredly will require.

Mr. Dowson, in the paper above referred to, was trying to convince gas engineers, and believing that facts are the stubbornest of all arguments, he adduced the results obtained at Dessau, saying: "I visited Dessau last autumn, and it is through the courtesy of the managing director (Herr W. von Oechelhauser) that I am able to give you the above results. In this country it is usual to allow 60 watts per hour for a 16-c.p. lamp; but on the Continent it is more common to allow only three watts per candle-power, or 48 watts per 16-c.p. lamp. At Dessau the actual consumption is under this. If, however, we take the English allowance of 60 watts to give the light of 16 candles, and if 41 cubic feet of gas are consumed to produce 1,000 watts as at Dessau, one of these lights will require under 2½ cubic feet per hour; whereas a standard argand burner requires five cubic feet, and an ordinary flat-flame burner considerably more. We see, therefore, that in actual working there is a saving of 50 per cent. in favour of burning

the gas in the engine, and in producing the light electrically in incandescent lamps."

The Dessau results referred to in this quotation were that, taken over an average of thirty days in December last, the consumption of gas was 40·82 cubic feet per kilowatt-hour generated at the terminals of the dynamos. This is a fact which, unless it can be shown to be erroneous, speaks volumes as to the value of burning gas in an engine in order to produce electric light. We are extremely surprised at the recent policy of gas-engine builders. They seem to imagine that electric light is played out, and put little or no energy into pushing business in this direction. But Mr. Dowson tells them that "electric lighting is no mere fad—it has come to stay and to grow; and although gas engineers would rather be without it, they know well enough that the world will go ahead and have what it believes to be best and what it prefers." The tendency of some of the best electrical engineers is to give gas-engines a more extended trial than hitherto, and to instal them for central-station work. There is no doubt about the accumulated proof of their value for isolated installations. We might suggest to the authorities at Nelson, one of the most go-ahead towns in Lancashire, that when additions are required to their electric lighting plant, as additions will be required, they have every opportunity of giving a thorough trial to gas-engines. They are the owners of the gasworks and the owners of the electric lighting works. Both works are, so to speak, in a ring fence—under the same management; and under these conditions admirably suited for giving Mr. Dowson's suggestions an exhaustive trial.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ACCUMULATOR TRACTION.

SIR,—Replying to Mr. Broekman's letter in your last week's issue, I would like to suggest that the question of the advantages of the accumulator system over any other form of traction is not to be proved by the bald statement, that the Epstein Accumulator Company have entered into an agreement with the Birmingham Central Tramways Company to maintain their cells at 1½d. per car mile.

The superiority of accumulators over any form of traction is best proved by the balance sheet of a tramway company using that system, and I look forward with much interest to the publication of the Birmingham Central Company's balance-sheet, shortly to be issued, to see how far that document agrees with the evidence given by Mr. Epstein before the Joint Committee of the Electric Power Protection Clauses as regards the economy of the accumulator system, and also with Mr. Broekman's statement that the working of the Bristol road section of the Birmingham Central Tramways is cheaper than other direct system, and more regular and reliable in working than any other section of that system of tramways.—Yours, etc.,

STEPHEN SELLON.

35, Parliament-street, S.W., July 4, 1893.

Magnet Armatures.—To overcome the residual magnetic effect in electromagnets, Mr. S. H. Stupakoff makes his magnets with a thin sheet of soft iron in between the poles and the armature. This is found sufficient to neutralise the effect of residual magnetism without perceptibly increasing the magnetic resistance.

POLARISATION OF PLATINUM ELECTRODES IN SULPHURIC ACID.*

BY JAMES B. HENDERSON, B.SC.

This investigation was begun about the beginning of February, 1893, at the instigation of Lord Kelvin, and was conducted in the physical laboratory of Glasgow University. The object of the investigation was to obtain the difference of potential between two platinum electrodes immersed in a solution of sulphuric acid immediately after the stoppage of a current which had been electrolysing the solution, and to find how this difference varied with a variation in the intensity of the current or in the strength of the solution.

Former experiments by Buff (*Poggendorff*, vol. 130, p. 341, 1867) and Fromme (*Wiedemann*, vol. 33, p. 80, 1888) have given for the maximum polarisation with platinum wires of very small surface in the electrolysis of dilute sulphuric acid 3·5 and 4·6 volts.

Dr. Franz Richarz, in a paper "On the Polarisation of Small Electrodes in Dilute Sulphuric Acid," read before the British Association at Bath (1888), says of the above: "In these experiments the polarisation is calculated from measurements of the intensity of the galvanic current during the electrolysis, tacitly assuming that the resistance of the decomposition cell is independent of the intensity of the galvanic current. The correctness of the supposition has not been proved. I tried experiments by similar methods, and obtained yet greater values of the polarisation; it was calculated with a current density of 12 amperes per square centimetre as 4·4 daniells (4·7 volts), and increased more and more with increasing intensity of the galvanic current. It is very improbable that this can be right. By supposing, however, that the resistance of the decomposition cell is not independent of the intensity, but decreases in a fixed manner with increasing intensity, the calculation of the same experiments gives small and constant values of polarisation."

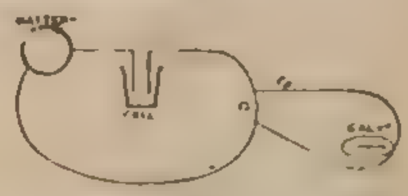


FIG. 1.

The method Dr. Richarz used to find the polarisation in his investigation was independent of the resistance of the electrolytic cell. The battery electrolytic cell and a switch, c_1, were joined in closed circuit. A branch circuit containing a very high resistance, a galvanometer, and another switch, c_2, joined the two sides of the switch c_1 (c_1 and c_2 were the two contacts of a Helmholtz's pendulum interrupter). When c_1 was made there was a very small current through the galvanometer. To determine the polarisation, c_1 was broken, and immediately after c_2 also. In the short time between the interruption of c_1 and c_2 a current strong for the sensibility of the galvanometer went through it. The polarisation was calculated from the deflection given to the galvanometer needle by the impact of the current, which was proportional to the E.M.F. of the battery, minus the polarisation. In this way Dr. Richarz found values for the polarisation never greater than 2·6 volts with small wire electrodes, and also got the same maximum with large platinum plates.

The cell used in the present investigation was a cylindrical glass vessel 10cm. diameter and 12cm. deep. The electrodes were rectangular plates of platinum foil 7cm. long by 5·5cm. broad, and were stiffened by being mounted on rectangular frames made by bending glass tubing, Fig. 2. The tubing of these frames also served to support the plates in vertical planes by being passed through holes in a bar of wood placed across the mouth of the vessel. The plates were immersed in the solution to a depth of 5cm., having their planes parallel and about 1cm.

* Paper read before the Royal Society. Communicated by Lord Kelvin, F.R.S.

apart. There were thus 55 square centimetres of surface of each plate wetted. To find the polarisation one of Lord Kelvin's quadrant electrometers was used, and by an arrangement, described later, the breaking of the electrolysing current circuit and the switching of the electrodes on to the terminals of the electrometer were done simultaneously. Before switching as above, however, the needle of the electrometer was deflected by making a difference of potential between the pairs of quadrants, and this deflection was so adjusted by trial and error that, when the electrodes were switched on, the needle was no farther deflected. For deflecting the needle of the electrometer a high resistance slide bridge was used. A difference of potential was maintained between its two ends, and the difference of potential between one end and the slider was used to deflect the needle, so that by moving the slider one way or the other the deflection could be increased or diminished at will. The electrolysing current was kept constant throughout each experiment, being measured by one of Lord Kelvin's electric balances and adjusted by a rheostat. One terminal of the electrometer, one electrode, and one end of the slide bridge were connected together and then put to earth. The current for the electrolysis was got from eight large secondary cells, and the difference of potential between the ends of the slide bridge was maintained by two small secondary cells. The arrangement of keys can be best understood from the diagram. By pressing the key k', connection was made between the slider and the unearthed quadrants, and when the key k was free the circuit was complete for the electrolysing current, but when k was pressed down the circuit was broken, and the unearthed electrode was connected to the unearthed quadrants.

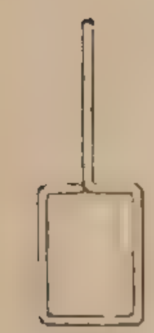


Fig. 2.

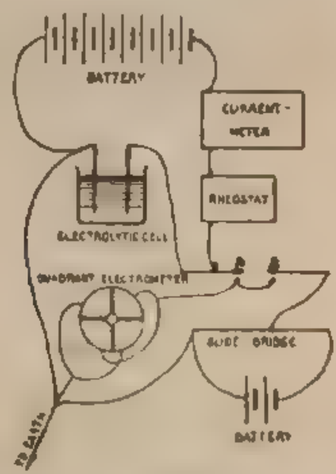


Fig. 3.

The order of an experiment was the following: After standardising the electrometer by means of a Clark cell the electrolysis was started, and the unearthed electrode connected by a wire (not shown in the diagram) to the unearthed quadrants. The deflection of the needle thus produced, which showed the difference of potential between the electrodes, continued to increase steadily until, after the lapse of an interval of time depending on the strength of the current, it became constant. When this stage was reached the wire mentioned above was removed and the key k' pressed and kept down, thus making connection between the slider and the quadrants. The slider was then moved along until the deflection was nearly equal to that which would be given by the polarisation, and the key k momentarily pressed, thereby breaking the current circuit and connecting the electrode to the quadrants. An impulsive deflection immediately followed, unless the potential of the quadrants was equal to that of polarisation. If this deflection was negative (which indicated that the potential of polarisation was less than that of the quadrants) the slider was moved so as to reduce the potential of the quadrants below that of polarisation, thereby making the impulsive deflection positive, and then the experiment was continued as below. When the positive deflection was obtained its amount was noted, and the slider was moved so as to *increase* the steady deflection nearly up to the point on the scale reached by the impulsive one, and another trial then made. In this way, by watching the point reached by each impulsive deflection, and then increasing the steady one almost up to that point, the latter was increased until the former vanished—that is, until the potential of the quadrants was that of polarisation. The magnitude of this deflection was then noted, and the polarisation calculated from it. In these trials the key k was kept down only for about two seconds, just sufficient time to allow the extent of the deflection to be seen, and at least two minutes were allowed to elapse between one trial and the next. After the maximum deflection had been reached, a considerable interval of time was allowed to elapse, and then the key k' raised and k simultaneously lowered and kept down, and the rate of fall of the deflection noted. The above motion of the keys threw the slider off and put the electrode on to the quadrants, at the same time stopping the current. The deflection was therefore due to polarisation alone, and its rate of fall was therefore the rate of fall of the polarisation.

The results of one series of experiments are given in the accompanying table. All the results point to the polarisation being constant with large electrodes, being independent of the strength of the solution and the intensity of the current. The variations in the figures do not occur in any order, and are all such as might be expected in experimental results of this nature. Some of the greatest variations were obtained in exactly similar experiments performed at different times. The mean of all the values of the polarisation in this table is 2·09 volts. The rate of fall of the polarisation depends on the time the current has been electrolysing the solution, and also on its intensity, but in every case the fall is very rapid at first, being in some cases as much in the first minute as it is in the next five minutes, and the fall in the first minute is never less than one-fourth of the polarisation.

Percentage strength of solution.	Strength of current in amperes.	Deflection for Clark cell.	Deflection for polarisation.	Time the current had been passing.	Polarisation in volts.
				h. m.	
[redacted]	0·2	111	160	3 25	2·066
,,	0·5	110	158	0 45	2·060
,,	1·0	110	158	0 35	2·060
,,	1·0	108	160	0 45	2·124
20	0·1	120	178	3 22	2·126
,,	0·5	120	179	1 25	2·139
,,	1·0	107	156	0 25	2·090
,,	1·0	108	160	0 35	2·124
10	0·1	120	179	17 40	2·139
,,	0·5	120	173	1 19	2·066
,,	1·0	120	173	0 44	2·066
5	0·1	124	183	18 30	2·116
,,	0·5	118	171	1 36	2·078
,,	1·0	117	170	1 0	2·083
,,	1·0	120	172	3 15	2·054

Mean polarisation = 2·09 volts.

THE ACTION OF COMPOUND DYNAMOS WHEN RUN IN PARALLEL.*

BY WILLIAM L. PUFFER, S.B.

While arranging some details of the wiring plan for connecting up two compounded railroad generators so that they could be tested for commercial efficiency while under the conditions of full load by one of the purely electrical methods, my attention was drawn to the fact that the usual method of adjusting such dynamos so that they would give a constant potential at their terminals, irrespective of the current flowing, could not be a correct one unless the machines were exactly alike in all respects.

The general practice is to over-compound such generators, and then to experimentally shunt the series coil with a German-silver ribbon until the desired "0 per cent. rise" is obtained; this is well enough for a single dynamo, but when two or more are in parallel, with their series coils also in parallel, the German-silver shunts do not in any

* From *Technology Quarterly*, vol. v., No. 4, December, 1892.

way aid the different dynamos in equalising their load, and any original structural difference will cause the load to divide unequally. I found that in all the power plants that I could then visit (winter of 1890 91) there was very decided evidence of this tendency to unequal division of the load, and it could readily be seen that some machines were always taking more than their share of an increase of load and tending to do too little when the load fell off. There seemed to be a very common knowledge of the trouble in making the dynamos work well together, but there seemed to be no attempt to help the matter, or, as far as I could find, any knowledge of where the fault was.

A year ago the Thomson-Houston Electric Company was so kind as to loan the institute a pair of similar over-compounded motor-type dynamos which had been adjusted for "0 per cent. rise"; these dynamos were similar to the power generators of that company, and enabled me to make a study of the action of compound generators connected in parallel. The dynamos were belt-driven from the main shaft in the dynamo-room of the physical department, and were under good average running conditions. A short piece of shafting was arranged so that by slipping the pulleys slightly the two armature shafts could be mechanically connected, and therefore must at all times be at the same speed. Suitable water resistances connected to each machine were used for varying the output of the armatures. Double pole jack-knife switches of the type generally used were provided for connecting the two dynamos in parallel.

and connections up to the distribution point or 'bus bar where the voltmeter was connected (curve 5). These separate losses may be plotted separately, and their sum will equal the amount that the net characteristic will fall below a horizontal line.

Inasmuch as the net characteristic in this combination is a very drooping one, it would be necessary to use hand or automatic means of adjusting the voltage as the current changes, so as to keep the mains at the normal value—the effect of this regulation can be considered to be a raising or lowering of the net characteristic bodily without any material change in the inclination. Such regulation is always too late by at least the time necessary to produce a change of the indicating device, yet if this amount is small and the demand for current is not very variable, such a combination is perfectly satisfactory, and even desirable, on account of the sudden fall of voltage on a short circuit, which lessens very materially the shock to all parts of the system.

A second similar combination can be connected in parallel to this first one, and the load divided between them—all that is necessary is to have the voltage of the incoming system very nearly equal to that of the 'bus bar or common point, and then to close the switches. Evidently, if the voltage of the new dynamo were just right, no current could pass in either way, but if it were somewhat too high then a part of the total current would change from the old dynamo to the new one. If, for example, the new dynamo

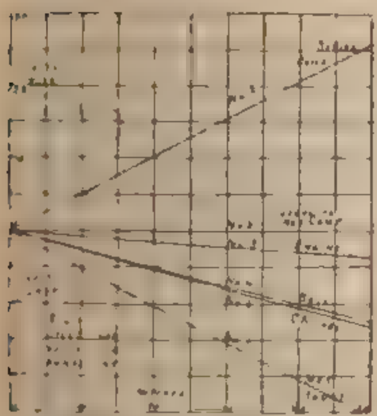


Fig. 1.

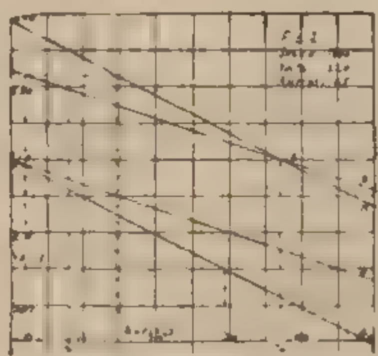


Fig. 2.

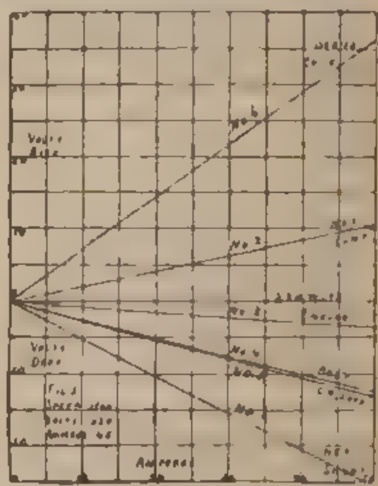


Fig. 3.

A dead-beat ammeter was placed in each armature circuit, and an Ayrton and Perry spring ammeter in the equalising wire. A Weston voltmeter was used in connection with pressure wires to measure the voltage of either armature.

The object of this paper is not to describe these tests, but rather to explain a method of investigating the action of compound dynamos in parallel, and to point out the cause of some of the difficulties commonly met with, as well as to show that it is comparatively a simple matter to avoid them; so that the results of these tests, although very interesting, will not be given except as explanatory examples.

Considering first the action of a single-shunt dynamo driven by a belt from an engine doing no other work, if now the load be gradually increased to the maximum amount that can be safely carried, and if from time to time simultaneous values of the current and voltage be taken and plotted as in Fig. 1, curve 1—for want of a better name let us call this the net characteristic curve of the combination—this curve would be a horizontal line (curve 2) if it were not for the sum of a number of actions, all of which tend to lower the E.M.F.; beginning at the engine there is the usual fall of speed as the load increases, due simply to the action of the governor (curve 3), the dynamo pulley lags behind more and more on account of the increasing slip of the belt as the transmitted power becomes greater, these two changes are plotted in curve 4; in the dynamo armature there are the usual demagnetising reactions which lower the E.M.F.; and finally, there is the fall of potential in the armature wires as well as all the necessary leads, fuses, ammeters,

were x volts higher than the old, then the current through it would be of such value as would cause a fall of $\frac{1}{2}x$ on the net characteristic, and the current from the old dynamo would be smaller by the same amount. When the net characteristic is quite drooping, as is always the case with shunt dynamos, there is little or no danger of even overloading an armature when connecting it to the mains—in fact, it is common practice in central stations to judge of the voltage of the new dynamo by the looks of its pilot lamp. If the two units (dynamo with its engine) have similar net characteristics, any change of load, sudden or not, will divide equally between them; but if, as usual, the characteristics are not similar this will not be the case, and we shall find that the unit with the steepest characteristic will not take its share of the work if the load increases, and will take more than its share with a decrease of load.

Let the lines A and B in Fig. 2 represent the net characteristics of the two units; when the armatures are in parallel and delivering no current, let the voltage be brought to 220 volts, then the two lines are common, as at a. A sudden current of 74 amperes will cause the voltage to drop to 205, and B will deliver 45, and A 29 amperes. If now the load is equalised with 37 amperes in each armature, and the voltage brought up to 220 by the use of the regulating rheostats, the lines A and B are raised to A^1 and B^1 respectively, being common at b; now let the total current be diminished from 74 amperes to 16·5 amperes, a similar construction shows that the voltage will rise to 231·6 volts, and that A will deliver 14·5 amperes, and B two amperes.

When two dynamos with net characteristics like these are subject to a rapidly-changing load, it is impossible to evenly divide the current, and a balance has to be struck between the limits, on the one hand, of the dynamo, A, driving B as a motor—which will, of course, do no especial harm other than to waste energy in heating and sparking—and, on the other hand, of melting the fuses of dynamo B during an unusually heavy call for power, which might have been safely carried by the fuses if equally divided. It is plain that in this case the combination of the two dynamos is not double the capacity of either one, and the commercial efficiency is considerably lessened by the want of similarity of the net characteristics.

It is very desirable on many accounts to have a dynamo which will automatically maintain an approximately constant potential at the switchboard irrespective of the amount of current flowing. We may add a series winding to the dynamo of just sufficient number of turns to give such a magnetising effect as will produce a voltage which shall be at all times exactly equal and opposite to the combined effects of the change in engine speed, belt slip, armature reactions, and the drop of voltage due to the resistance of the armatures, lead wires, ammeter, safety devices, and the like, up to the 'bus bar (Fig. 1, curve 6). The net characteristics will now be made up of the sum of the individual effects, as shown in Fig. 1, curve 2, and the voltage at the switchboard would be constant at all times were it not for the hysteresis of the iron in the magnets, which will very slightly prevent the instantaneous rising and falling of the effect of the series coils, and any change in resistance due to temperature change. The temperature change will be slow, and is corrected by an occasional change of the rheostat in the shunt-coil circuit, and can be neglected for the present.

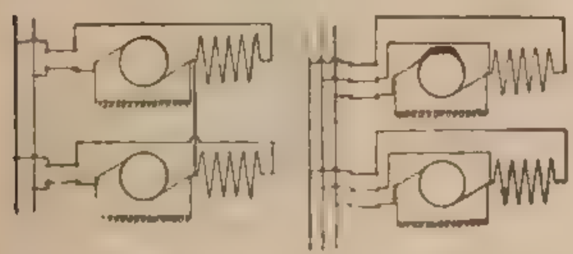


Fig. 4. Fig. 5.

Should it be necessary to use a second dynamo of exactly similar design, we cannot proceed as in the case of simple shunt dynamos, for this reason: If the new dynamo is at exactly the same voltage as the mains at the switchboard when connected in parallel, the combination will be unstable, because if for any cause the voltage of either dynamo varies a little, so that the new machine becomes ever so slightly a motor, the effect of the reverse current in its series coil will be to weaken still more the E.M.F., which will allow an increasing current to flow until something burns out.

If, however, there is a third connection made so that the brushes as well as the terminals of the two dynamos are connected, it becomes impossible for this reversal to happen, and the machines will run perfectly under all changes of load. There are in use two ways of arranging the switches, Figs. 4 and 5, either of which is satisfactory; but the one shown in Fig. 5 is better, as the idle machine is completely disconnected from the circuits.

An examination of the components of the net characteristics, Fig. 1, curve 2, shows us that if the incoming dynamo be brought up to the voltage of the switchboard, and the switch closed, the load will instantly divide between the two dynamos with no disturbance or shock of any kind. Suppose, for instance, that the loaded machine is giving out 40 amperes, we see from the net shunt characteristic, Fig. 1, curve 1, that there is a drop of 20·5 volts, which is made up by the effect of the series coil, curve 6, giving a terminal potential of 220 volts. When the new machine at 220 volts is switched in parallel, we may first consider that one half the total current of 40 amperes passes through each of the parallel series coils, and from curve 6 we see that the volts rise is cut down from 20·5 to 10·2 in the first dynamo and raised from zero to 10·2 in the new one; from curve 1 we see that for each dynamo this change of 10·2 volts just compensates for a current of 20 amperes through the armature circuits, and that the total load of 40 amperes at 220 volts will be equally divided between the dynamos.

The action of compound constant-potential dynamos in parallel is generally misunderstood, and the equalising connection is credited with a remarkable power of control over the output of such dynamos which it does not and cannot have, as can be seen by watching the dynamos while at work as well as by examination of the make-up of the net characteristic, Fig. 1. The common idea is that the equaliser has the property of compelling a lagging dynamo to take its share of the work, and we hear of the wonderful power of control which it has even over dynamos of different types and sizes running under somewhat different conditions. Now the real effect of the equaliser is to put the series coils in parallel, so that the total flow of current from the plant will divide between them inversely as their resistance without any regard as to whether this current comes from one armature alone or is divided among many, and hence it follows that it cannot in any way exercise even the slightest regulating effect on any one dynamo that it does not have over all the rest. The armatures themselves are running in parallel under the usual conditions of ordinary shunt dynamos, and the total current will divide between them under the same laws that would hold if there were no series coils at all and the current were taken from the two main wires to which the brushes are connected, as has been already pointed out in a previous part of this article.

The net characteristic of the plant is then a falling one, as far as the armatures are concerned, to which has been added the automatic regulation of the parallel series coils which act together in proportion to the total flow of current from the station; and if these series coils are all alike in effect, each dynamo will have its voltage altered by an equal amount in proportion to the output of the station, but each armature will not do its share of the work unless all the net falling characteristics are exactly similar.

In a plant of such dynamos, each driven by its own engine, it is most likely that the net falling characteristics of the armatures will not all have the same steepness, and consequently a fluctuating load will not be shared equally by the dynamos; but it is possible to so arrange things that the series coils do not all act equally on the armatures, and if the resistances of the series coils are slightly changed by the addition of a little German-silver or copper ribbon, so that the total flow of current divides between the different series coils in such a proportion that the individual net armature characteristics are raised by just the right amount, we again have a plant in which a fluctuating load will divide equally among the different dynamos. The same effect may be produced by the addition of a small resistance in the armature circuit of any dynamo which takes more than its share of an increase of load. A number of machines so adjusted will run together perfectly, and there will be no change of voltage or any difficulty experienced in cutting in or out by the use of the ordinary two or three pole switch; the only precaution to be observed is to have the voltage of a new machine nearly that of the 'bus bars, for then, when the series coil is put in parallel with all other series coils, it will be traversed by such a part of the total flow of current as will be sufficient to raise the voltage of the armature enough to enable it to deliver its share of the total output.

If a dynamo is to be cut out it will not do to reduce its load first by the use of the resistance in the field circuit, because by this process its load is transferred to the other dynamo armatures and the station voltage will consequently fall somewhat, because the series coils are not proportionately increased. This fall of voltage may or may not be permissible, and is avoided if the switch is opened while the dynamo has its share of the load.

Sometimes it is desirable to have a dynamo which will maintain a constant potential at a point some distance from the switchboard; in this case the series coils will have a few more turns, so as to make up for the fall of potential in the mains; and in Fig. 3 will be found the component curves

for a dynamo adjusted for approximately "5 per cent. rise." Curve 1 may be called the "net shunt" falling characteristic made up of the sum of the effects due to the engine change, belt slip, and the fall of potential in the armature circuits represented respectively by the curves 3, 4, and 5. Curve 6 shows the rise of voltage due to the current in the series coils, and is greater than the total drop, curve 1, by an amount plotted as curve 2, which is the net characteristic of the over-compounded dynamo.

Should the demand for current exceed the capacity of one dynamo, the addition of a duplicate machine will render it impossible to maintain a constant potential at the distant centre unless both dynamos are run all the time; for while 45 amperes on one dynamo will cause a net rise at the switchboard of 9·5 volts, the same total current furnished by the pair will only produce a rise of 4·75 volts.

If this want of exact regulation does not require the constant running of two dynamos at times of light load, we meet greater troubles in the process of adding the second unit when the load is too heavy for the first one. From the data given in Fig. 3 it is possible to see what will happen under any given conditions when the machines are put in parallel. I have experimentally verified this method of predicting the actions of compound dynamos, and find it exact enough for all practical purposes.

Suppose one dynamo is loaded, what will be the effect if we connect a new one when its voltage is lower, the same as or higher than the switchboard? I will take from my note-book the results of some experiments on two dynamos with characteristic curves like Fig. 3, first giving the observed results, and then calculating them from the curves.

The armatures were mechanically coupled, and therefore at the same speed. Voltage of each was 222; 30 amperes were taken from No. 2 dynamo, and voltage rose to 228, while that of No. 1 fell to 212; then by a double-pole switch No. 1 was put in parallel. Momentarily No. 2 tended to overload and drive No. 1 as a motor, but in a few seconds the load became steady at a voltage of 222, No. 1 furnishing 18 and No. 2 12 amperes. Now by calculation from curves of Fig. 3:

No. 1.	No. 2.	
222	222	Volts at switchboard with no load.
- 7·5	- 7·5	Curve 4. Drop due to speed change when a current of 30 amperes was taken from No. 2.
214·5	214 5	
	- 8	Curve 5. Armature drop with 30 amperes.
	206 5	
	+ 21 5	Curve 6. Rise from 30 amperes in series coils.
	228·0	Switchboard voltage with 30 amperes output.

Put in parallel with same load, so no change is to be made for speed change. From curve 6 we see that the change of half of the current from the series coil of No. 2 to No. 1 will raise No. 1.

No. 1.	No. 2.	
214·5	228·0	No. 1 with no load and 30 amperes on No. 2, and then put in parallel.
+ 12·0	- 12·0	Curve 6. Change in voltage with change of half current from series coils of No. 2 to series coils of No. 1.
226·5	216·0	
- 4·	+ 4·	Curve 5 Suppose each armature carried one half the current, then there would be a drop in No. 1 and a rise in No. 2.
222·5	220·0	

We must now add a current to the highest voltage dynamo, or No. 1, that will cause a drop of one-half of 222 5—220 volts, which from curve 5 will be 4·7 amperes.

Then the voltage of the combination will be 221·2; and dynamo 1 will deliver 15 + 4·7 = 19·7 amperes, and dynamo 2, 15 - 4 7 = 10 3 amperes.

Calculated 19·7 amperes, dynamo 1. 10·3 amperes, dynamo 2. Voltage of 221·2.
Measured 18 amperes, dynamo 1. 12 amperes, dynamo 2. Voltage of 222.

Take, for another example, the case when one of these dynamos was at full load, and the new machine was brought up to exact voltage and then put in parallel, and applying these methods we shall see that it may happen that all current may be cut off by the melting of a fuse.

Dynamo No. 1 at 220 volts and no load, then as the load of 45 amperes comes on, the switchboard voltage will be about 230 volts.

220	
- 11·2	Drop due to load. Curve 4.
208 8	
- 11·7	Drop in armature. Curve 5.
197 1	
+ 32 5	Rise from series coil. Curve 6.
229 6	Volts at switchboard.

Here the switch is closed.

No. 1		No. 2	
229 6		229·6	
- 16·2	22½ amperes in series coil. Curve 6	+ 16 2	
213·4		245·8	Armature voltage.
+ 11 7	Curve 5, to find internal voltage.		
225·1	Armature voltage.		

245 8	Armature voltage No. 2.
225 1	Armature voltage No. 1.
20 7	Difference of armature voltages.
11·7	Drop in No. 2 with 45 amperes.
2) 9·0	Acting to send reverse current through No. 1.
4·5	Curve 5 corresponds to current of about 17 amperes.
245·8	Armature voltage No. 2.
- 17·0	Drop with 62 amperes. Curve 5.
228·8	Switchboard voltage.

Dynamo No. 1, which was loaded, has a reverse current of 17 amperes, and is driven as a motor, while the new dynamo carries the load and is 17 amperes beyond its rated capacity. We see that the switchboard voltage practically does not change under these conditions, but to offset this there is the sudden change of a loaded dynamo into a partially loaded motor and an overload on the incoming dynamo. Such changes would be accompanied by much sparking at the brushes and the liability of thrown belts or blown fuses. Then we may say that if the new dynamo is of lower voltage when connected the voltage will change considerably, but there will be no shock to the dynamos; if the new dynamo is at the same voltage then the voltage will remain about constant and the armatures will receive a shock; if the new machine is still higher, then the shock will be very severe and the voltage will rise. I had no time for taking readings on the last experiment, but I did notice that the needle of a 150-ampere instrument was out of sight before a switch could be opened.

(To be continued.)

ON LIGHT AND OTHER HIGH-FREQUENCY PHENOMENA.*

BY NIKOLA TESLA.

(Continued from page 650, Vol XI.)

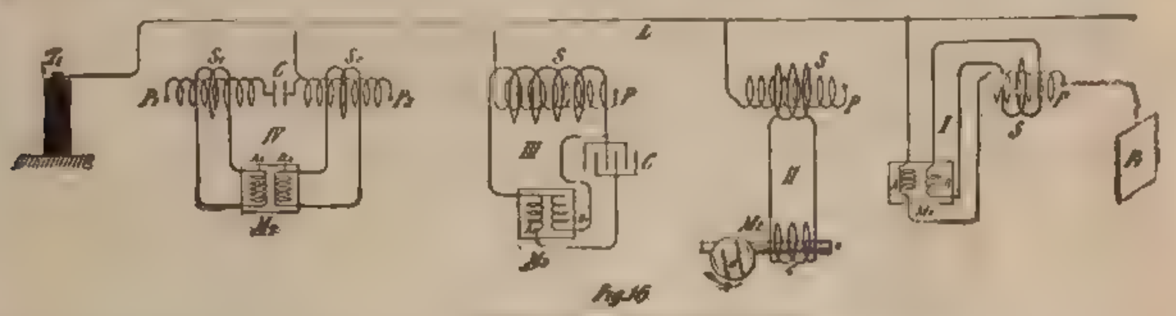
The preceding experiments will have prepared one for the next following results of interest obtained in the course of these investigations. Since I can pass a current through an insulated wire merely by connecting one of its ends to the source of electrical energy, since I can induce by it another current, magnetise an iron core, and, in short, perform all operations as though a return circuit were used, clearly I can also drive a motor by the aid of only one wire. On a former occasion I have described a simple form of motor comprising a single exciting coil, an iron core and disc. Fig. 16 illustrates a modified way of operating such an alternate-current motor by currents induced in a transformer connected to one lead, and several other arrangements of circuits for operating a certain class of alternate motors founded on the action of currents of differing phase. In view of the present state of the art it is thought sufficient to describe these arrangements in a few words only. In the diagram, Fig 16 II., shows a primary coil, P, connected with one of its ends to the line, L, leading from a high-tension transformer terminal, T_1. In inductive relation to this primary, P, is a secondary, S, of coarse wire, in the circuit of which is a coil, *c*. The currents induced in the secondary energise the iron core, *i*, which is preferably, but not necessarily, subdivided, and set the metal disc, *d*, in rotation. Such a motor, M_2, as diagrammatically shown in Fig. 16 II., has been called a "magnetic

* A lecture delivered before the Franklin Institute, at Philadelphia, February 24, 1893; and before the National Electric Light Association, at St. Louis, Mo., March 1, 1893.

lag motor," but this expression may be objected to by those who attribute the rotation of the disc to eddy currents circulating in minute paths when the core, *i*, is finally subdivided. In order to operate such a motor effectively on the plan indicated, the frequencies should not be too high, not more than 4,000 or 5,000, though the rotation is produced even with 10,000 per second, or more.

In Fig. 16 I., a motor, M_1, having two energising circuits, A and B, is diagrammatically indicated. The circuit A is connected to the line, L, and in series with it is a primary, P, which may have its free end connected to an insulated plate, P_1, such connection being indicated by the dotted lines. The other motor circuit, B, is connected to the secondary, S, which is in inductive relation to the primary, P. When the transformer terminal T_1, is alternately electrified, currents traverse the open line, L, and also circuit A and primary, P. The currents through the latter induce secondary currents in the circuit, S, which pass through the energising coil, B, of the motor. The currents through the secondary, S, and those through the primary, P, differ in phase 90deg., or nearly so, and are capable of rotating an armature placed in inductive relation to the circuits, A and B.

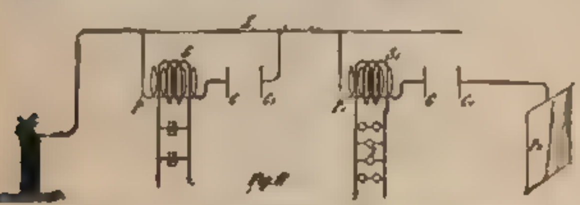
the other end to the condenser plates, C and C^1, respectively. Near these are placed other condenser plates, C_1 and C_1^1, the former being connected to the line, L, and the latter to an insulated larger plate, P_2. On the primaries are wound secondaries, S and S_1, of coarse wire, connected to the devices *m* and *d* respectively. By varying the distances of the condenser plates, C and C^1, and C_1 and C_1^1, the currents through the secondaries, S and S_1, are varied in intensity. The curious feature is the great sensitiveness, the slightest change in the distance of the plates producing considerable variations in the intensity or strength of the currents. The sensitiveness may be rendered extreme by making the frequency such that the primary itself without any plate attached to its free end satisfies, in conjunction with the closed secondary the condition of resonance. In such condition an extremely small change in the capacity of the free terminal produces great variations. For instance, I have been able to adjust the conditions so that the mere approach of a person to the coil produces a considerable change in the brightness of the lamps attached to the secondary. Such observations and experiments possess of course at present chiefly scientific interest, but they may soon become of practical importance.



Ways of Operating Motors with only One Lead.

In Fig. 16 III., a similar motor, M_3, with two energising circuits, A_1 and B_1, is illustrated. A primary, P, connected with one of its ends to the line, L, has a secondary, S, which is preferably wound for a tolerably high E.M.F., and to which the two energising circuits of the motor are connected, one directly to the ends of the secondary and the other through a condenser, C, by the action of which the currents traversing the circuit, A_1 and B_1, are made to differ in phase.

In Fig. 16 IV. still another arrangement is shown. In this case two primaries, P_1 and P_2, are connected to the line, L—one through a condenser, C, of small capacity, and the other directly. The primaries are provided with secondaries, S_1 and S_2, which are in series with the energising circuits, A_2 and B_2, and a motor, M_2, the condenser, C, again serving to produce the requisite difference in the phase of the currents traversing the motor circuits. As such phase motors with two or more circuits are now well known in the art, they have been here illustrated diagrammatically. No difficulty whatever is found in operating a motor in the manner indicated or in similar ways, and although such experiments up to this day present only scientific interest, they may at a period not far distant, be carried out with practical objects in view.



Single Wire Conversion and Distribution, with Simple Means for Regulating the Effects.

It is thought useful to devote here a few remarks to the subject of operating devices of all kinds by means of only one leading wire. It is quite obvious, that when high frequency currents are made use of, ground connections are—at least when the E.M.F. of the currents is great—better than a return wire. Such ground connections are objectionable with steady or low-frequency currents on account of destructive chemical actions of the former and disturbing influences exerted by both on the neighbouring circuits, but with high frequencies these actions practically do not exist. Still, even ground connections become superfluous when the E.M.F. is very high, for soon a condition is reached when the current may be passed more economically through open than through closed conductors. Remote as might seem an industrial application of such single wire transmission of energy to one not experienced in such lines of experiment, it will not seem so to anyone who for some time has carried on investigations of such nature. Indeed, I cannot see why such a plan should not be practicable. Nor should it be thought that for carrying out such a plan currents of very high frequency are implicitly required, for just as soon as potentials of, say, 30,000 volts are used, the single-wire transmission may be effected with low frequencies, and experiments have been made by me from which these inferences are made.

When the frequencies are very high it has been found in laboratory practice quite easy to regulate the effects in the manner shown in diagram, Fig. 17. Here two primaries, P and P, are shown, each connected with one of its ends to the line, L, and with

Very high frequencies are, of course, not practicable with motors on account of the necessity of employing iron cores. But one may use sudden discharges of low frequency and thus obtain certain advantages of high frequency currents without rendering the iron core entirely incapable of following the changes, and without entailing a very great expenditure of energy to the core. I have found it quite practicable to operate with such low frequency disruptive discharges of condensers alternating current motors. A certain class of such motors which I advanced a few years ago, which contain closed secondary circuits, will rotate quite vigorously when the discharges are directed through the exciting coils. One reason that such a motor operates so well with these discharges is that the difference of phase between the primary and secondary currents is 90deg., which is generally not the case with harmonically rising and falling currents of low frequency. It might not be without interest to show an experiment with a simple motor of this kind, inasmuch as it is commonly thought that disruptive discharges are unsuitable for such purposes. The motor is illustrated in Fig. 18. It comprises a rather large iron core, *i*, with slots on the top into which are embedded thick copper washers, *c c*. In proximity to the core is

Operating a Motor by Disruptive Discharges.

a freely movable metal disc, D. The core is provided with a primary exciting coil, C, the ends, *a* and *b*, of which are connected to the terminals of the secondary, S, of an ordinary transformer, the primary, P, of the latter being connected to an alternating distribution circuit or generator, G, of low or moderate frequency. The terminals of the secondary, S, are attached to a condenser, C, which discharges through an air-gap, *d d*, which may be placed in series or shunt to the coil C. When the conditions are properly chosen the disc, D, rotates with considerable effort and the iron core, *i*, does not get very perceptibly hot. With currents from a high frequency alternator, on the contrary, the core gets rapidly hot and the disc rotates with a much smaller effort. To perform the experiment properly it should be first ascertained that the disc, D, is not set in rotation when the discharge is not occurring at *d d*. It is preferable to use a large iron core and a condenser of large capacity so as to bring the superimposed quicker oscillation to a very low pitch, or to do away with it entirely. By observing certain elementary rules I have also found it practicable to operate ordinary series or shunt direct-current motors with such disruptive discharges, and this can be done with or without a return wire.

Among the various current phenomena observed perhaps the most interesting are those of impedance presented by conductors to currents varying at a rapid rate. In my first paper before the American Institute of Electrical Engineers, I have described a few striking observations of this kind. Thus I showed that when such currents or sudden discharges are passed through a thick metal

bar there may be points at the bar only a few inches apart, which have a sufficient potential difference between them to maintain at bright incandescence an ordinary filament lamp. I have also described the curious behaviour of rarefied gas surrounding a conductor to such sudden rushes of current. These phenomena have been since more carefully studied, and one or two novel experiments of this kind are deemed of sufficient interest to be described.

With reference to Fig. 19a, B and B_1 are very stout copper bars connected at their lower ends to plates, C and C_1, respectively, of a condenser, the opposite plates of the latter being connected to the terminals of the secondary, S, of a high tension transformer, the primary, P, of which is supplied with alternating currents from an ordinary low frequency dynamo, G, or distribution circuit. The condenser discharges through an adjustable gap, $d\ d$, as usual. By establishing a rapid vibration it was found quite easy to perform the following curious experiment. The bars, B and B_1, were joined at the top by a low voltage lamp, l_3; a little lower was placed by means of clamps, $c\ c$, a 50 volt lamp, l_2, and still lower another 100 volt lamp, l_1, and finally at a certain distance below the latter lamp, an exhausted tube, T. By carefully determining the positions of these devices it was found practicable to maintain them all at their proper illuminating power. Yet they were all connected in multiple arc to the two stout copper bars and required widely different pressures. This experiment requires, of course, some time for adjustment, but is quite easily performed.

Fig 19a. Fig 19b. Fig 19c.

Impedance Phenomena.

In Figs. 19b and 19c, two other experiments are illustrated, which, unlike the previous experiment, do not require very careful adjustments. In Fig. 20b, two lamps, l and l_1 (the former a 100 volt and the latter a 50 volt) are placed in certain positions as indicated, the 100 volt lamp being below the 50 volt lamp. When the arc is playing at $d\ d$, and the sudden discharges passed through the bars, B B, the 50 volt lamp will as a rule burn brightly, or at least this result is easily secured, while the 100 volt lamp will burn very low or remain quite dark, Fig. 19b. Now the bars, B B, may be joined at the top by a thick cross bar, B_2, and it is quite easy to maintain the 100 volt lamp at full candle power while the 50 volt lamp remains dark, Fig. 19c. These results, as I have pointed out previously, should not be considered to be due exactly to frequency, but rather to the time rate of change which may be great even with low frequencies. A great many other results of the same kind equally interesting, especially to those who are only used to manipulate steady currents, may be obtained, and they afford precious clues in investigating the nature of electric currents.

In the preceding experiments I have already had occasion to show some light phenomena, and it would be now proper to study these in particular; but to make this investigation more complete I think it necessary to first make a few remarks on the subject of electrical resonance, which has to be always observed in carrying out these experiments.

(To be continued.)

PHYSICAL SOCIETY.—June 23, 1893.

Prof. A. W. Rücker, M.A., F.R.S., President, in the chair.

Prof. J. Cox, M.A., was elected a member of the society.

Mr. F. H. Nalder exhibited a bridge and commutator for comparing resistances by Prof. Carey-Foster's method, the chief features of which are simplicity, compactness, long range, and great accuracy. The commutation of the coils to be compared is effected by mercury cups, the eight holes necessary for this purpose being arranged in a circle. An ebonite disc carrying the four connectors is mounted on a spindle in the middle of the circle, and the positions of the coils are interchanged by rotating the disc through 180deg. A large range is secured by providing a number of interchangeable bridge wires, and a fine adjustment for the galvanometer key enables great accuracy to be attained.

Mr. W. R. Pidgeon and **Mr. J. Wimshurst** each read a paper on "**An Influence Machine**," and exhibited their machines in action. In designing his machine Mr. Pidgeon has endeavoured (1) to make the capacity of each sector large when being charged, and small when being discharged; (2) to prevent leakage from sector to sector as they enter or leave the different fields of induction; and (3) to increase the capacity of the machine by making the sectors large and numerous. The first object is attained by arranging fixed inductors of opposite sign to the sectors near the charging points, and of the same sign near the places of discharge. Objects (2) and (3) are secured by embedding the sectors in wax, run in channels in the ebonite discs which form the plates of the machine, and carrying wires from each sector through the ebonite, each wire terminating in a knob. In this way the sectors can be placed much nearer together than otherwise without sparking back. By setting the sectors skew with the radius, they are caused to enter the electric fields more gradually, consequently the potential difference between adjacent sectors is kept comparatively small. Experiment showed that the use of the stationary inductors at the charging points increased the output threefold, and as compared within an ordinary Wimshurst the output for a given area of plate passing the conductors was as 5·6 : 1. The recovery of the machine after a spark had occurred was particularly rapid. Mr. Wimshurst's new machine consists of two glass discs 3ft. 5in. diameter, mounted about ¾in. apart on the same spindle. Both plates turn in the same direction. Between the discs are fixed four vertical glass slips over 4ft. long, two on each side, and each covering about three-eighths of a disc. Each slip carries a tinfoil inductor, which has a brush touching lightly on the inside of the adjacent disc, on its leading edge. Collecting and neutralising brushes touch the outsides of the discs and the few metallic sectors attached thereto. An account of some experiments made to determine the efficiency of the machine was given. The author also showed that when all the circuits of the machine were broken, it still continued to excite itself freely, and sparked from the discs to the hands when brought near.

In a written communication, **Prof. O. Lodge** said his assistant, Mr. E. E. Robinson, constructed a machine on lines similar to Mr. Pidgeon's a few months ago, and had now a large one nearly completed. Mr. Robinson's fixed inductors are carried on a third plate fixed between the two movable ones. The sectors are quite small, and neither they nor the inductors are embedded. On close circuit the machine gives a large current ($\frac{1}{20000}$ ampere) and on open circuit exceedingly high potentials. In Dr. Lodge's opinion, Mr. Pidgeon attaches too much importance to his sectors and their shape.

Mr. J. Gray wrote to say that stationary inductors enclosed in insulating material would probably give trouble at high voltages, because of the surface of the insulator becoming charged with electricity of opposite sign to that on the inductor. He suggested that this might explain why Mr. Pidgeon could not obtain very long sparks.

Prof. C. V. Boys enquired as to how far the wax made insulating union with the ebonite, for if good, glass might possibly be used instead of ebonite. He greatly appreciated the design of Mr. Pidgeon's machine.

A paper on "**A New Volumenometer**" by **Mr. J. E. Myers, B.Sc.**, describing the developed form of Prof. Stroud's instrument was, in the absence of the author, taken as read.

Mr. R. W. Paul exhibited a compact form of sulphuric acid voltameter of small resistance. The voltameter is a modification of a pattern designed at the Central Institution, in which the rate of decomposition is determined from the time required to fill a bulb made in the stem of a thistle funnel. He also showed a handy form of Daniell cell devised by Prof. Barrett. When not in use, the porous pot containing the zinc is removed from the copper sulphate solution and placed in a vessel containing zinc sulphate or sulphuric acid.

A paper on "**Long Distance Telephony**," by **Prof. J. Perry, F.R.S.**, assisted by **Mr. H. A. Beeston**, was read by Prof. Perry. The case of a line of infinite length, having resistance, capacity, self-induction, and leakage, is taken up, and the state of a signal as it gets further and further away from the origin is considered. Taking the shrillest and gravest notes of the human voice to have frequencies of about 950 and 95 respectively, the distance from the origin at which the ratio of the amplitudes of these high and low frequency currents is lessened by 1/mth of itself, has been determined when $m = 4$ for different values of leakage and self induction; and under similar conditions the distances at which the relative phase of the two currents become altered by 1/nth of the periodic time of the most rapid one, have been worked out for $n = 6$. The results are given in the form of tables, from which it appears that, if there was no self induction, increasing the leakage increases the distance to which we can telephone, whilst if there was no leakage, increasing the self induction increases the distance. When self induction and leakage are not too great, increasing either increases the distance, and for particular values the distances become very large. At the end of the paper, tables of general application are given, from which the limiting distances for any line can be readily found by multiplying the numbers by simple functions of the constants of the line.

COMPANIES' MEETINGS.

ELECTRIC CONSTRUCTION CORPORATION, LIMITED.

In our last issue we reproduced the circulars issued by the Directors of this Corporation with regard to the proposed reconstruction of the Company. In accordance with these circulars, meetings were held on Wednesday at the offices of the Corporation, at Worcester House, Walbrook, of the holders of first and second mortgage debentures, when the resolutions mentioned in the circulars were passed.

A meeting of the shareholders was subsequently held at the Cannon-street Hotel, Sir Daniel Cooper, Bart. (chairman), presiding.

The Chairman said that he had expressed on the occasion of the last meeting that the Board was in course of being reconstituted. The Board had been reconstituted, and during the past year seven gentlemen had retired from the Board, and three new Directors—Mr Bennett, Mr Barclay, and Mr Garcke—had been appointed. There was therefore practically a new Board, and he was very grateful for the changes that had been made. He had had occasion to mention at the last general meeting that Mr Courtenay had during the difficult period of transition taken up the reins of management, and had prepared the way for the Corporation making the important changes referred to. Since then he had been assisted by the new Directors, and the Board considered that they had been fortunate in securing the services of Mr Garcke as managing director. One of the first things that had had to be done was to cut down the very heavy standing charges, and the Managing Director would tell them what had been done in the direction of effecting economies. Then the financial position presented many difficulties, and it was only by the Directors coming forward and assisting the Corporation, and undertaking responsibilities for the Corporation, that they were able to meet their various engagements. The result of their investigation was that a thorough reorganisation of the business, and a reconstruction of the Company was absolutely necessary. The Board were convinced that the best way to carry out the reorganisation was by means of the scheme of reconstruction now before them, and by the formation of a new company. At present the credit of the Company was prejudiced by the shares being at a large discount, and this made it very difficult for the managers to get contracts and to carry on the business economically. The position of the Company was by no means what the price of the shares indicated, and he was expressing the views of his colleagues as well of himself when he stated that it was their belief that, with the careful management and energy with which they intended to push the business, there was a prosperous future before the new Company. The important contracts which had been entrusted to them, and which they had carried out successfully, by the aid of their works director (Mr Parker), had laid the foundation of profitable work in future. He then proposed the first special resolution: "That it is desirable that the Corporation be reconstructed, and that with a view to such reconstruction the Corporation be wound up voluntarily."

Mr Emile Garcke (the managing director) in responding to the call of the Chairman, hoped to give them reliable evidence that the Corporation had turned over a new leaf, and that there was reason for the hope that the errors of the past would not be continued in the future. He said that the new Board had acted very much in the capacity of a committee of investigation. A thorough reorganisation of the business had been taken in hand, and that would show the wisdom of the course taken at the last general meeting in leaving it to the new Board to carry out the investigation that they all felt necessary, particularly as the Directors had been able, in the course of their investigations, to put into effect such reforms as the result of their investigations proved to be desirable. With regard to the position of the Company when the new Board entered upon its work a few months ago, he mentioned that generally, while they were bound to recognise that there had been mismanagement in the past, the Directors were satisfied that, with strict economy and prudent management in the future, there was no reason whatever why they should not retrieve the errors of the past and occupy a leading position, and in many respects, the leading position in the electrical industry. It was difficulty to realise how very extensive had been the reorganisation of the Company's affairs. Some of the interests of the Corporation had been in the hands of separate companies with organisations of their own, and although the Corporation had the responsibilities of financing these subsidiary companies, they had not the full control of their management. Another disadvantage of this position was that the expenses of administration were unnecessarily and even excessively high, and the transactions between these several companies and the parent Corporation resulted in complications very often difficult to unravel. One of the first duties therefore, of the new Board was to get control of these subsidiary companies in such a way that they could reduce the expenses and minimise the friction, and very considerable progress had been made in this direction. Most of the subsidiary companies were now under the direct control of the Board, and, instead of there being separate officials the work of the subsidiary companies was largely done by the present staff of the Corporation. In this way very great savings had been effected. The financial position of the Corporation also at that time was not at all satisfactory, apart from the claims which these subsidiary companies made upon the Corporation, there were numerous liabilities and claims which were not properly defined, and which had been neglected. There again the Board had succeeded in improving the position. They had consolidated the liabilities of the Company in such a way that they were now in a far better position for dealing with them; but the settlement of many of those matters had involved the locking up of large sums of money in various securities and properties. There was still much to be done before they would be in what the Board considered a thoroughly sound financial and commercial position; but after what they had gone through and accomplished they were not going to be discouraged by the lesser difficulties still lying before them. Many of their investments were of such a character that, if properly developed and taken care of, promised not only to become valuable and realisable in cash, but would, he hoped, have the effect of largely increasing the business of the Corporation. They included shares and debentures in electric lighting companies, electrical and chemical manufacturing companies, tramway companies, and other concerns. Some of these were really fine properties, and brought in satisfactory dividends without causing much trouble. Others, however, might not be so good. In the first instance, the Electrical Power Storage Company, of which the Corporation held a large proportion of the capital, yielded them annually sufficient to pay the full interest on the first mortgage debentures. Another company, about which, however, they did not feel quite so happy, was the General Electric Power and Traction Company. They had a large stake in that company, some of which must be looked upon as lost, but that was provided for in the valuations upon which the scheme of reconstruction was based. Among the electricity supply companies in which they had shares and debentures were the Chelsea Electricity Supply Company, the Oxford Electric Company, and the Crystal Palace District Electric Supply Company. The first of these was now paying dividends, and the other two possessed successful electric light stations which were now rapidly increasing the number of lights. Then there were several subsidiary companies formed to develop electro-chemical patents of great promise, in which they had large interests. If these turned out successful, good profits should be made, and personally he had much confidence in the future of the electro-chemical industry. Another investment their predecessors had made was in the South Staffordshire Electric Tramways. This would, he thought, prove remunerative eventually, and would no doubt lead to their getting further business, but, nevertheless, in the present form it was an inconvenient lock-up of capital. Electric traction was going to be a very important industry, and from that point of view it was very desirable that they should be first in the field. Coming to consider the scheme of reconstruction, the Board had first in view the preparation of a scheme which should be fair and equitable to all interests. It had received the most careful consideration of the Board and of their legal advisers, and they were much gratified by the general support which had been given to it by the shareholders as well as by the debenture holders. At the two meetings that morning the proceedings passed off satisfactorily. Of the £150,000 debentures, only £126,000 had been subscribed and paid for, as mentioned in the schedule. The balance of £24,000 had not been taken up, but had been issued by the Corporation and deposited as security for advances. Upon these claims being paid off those debentures would be released and would be available for issue. Then of the £100,000 second mortgage debentures, only £50,000 were taken up last December, and the other £50,000 remained in the hands of the Company. Since then this second £50,000 had been deposited as security in consideration of advances made to the Corporation or liabilities undertaken on behalf of the Corporation. The first and second mortgage debentures would remain untouched. With regard to the income bonds, their conversion into ordinary shares was a desirable arrangement in the interests of the ordinary shareholders. It was true the ordinary shares to be issued in lieu of the income bonds would immediately rank for dividend, which was an advantage to the holders of the income bonds, but on the other hand, they gave up their claim to rank in front of the ordinary shares in a distribution of assets, and they also gave up their right to be paid off. That was very important to the ordinary shareholders. It was unfortunate that the burden of the loss should fall upon the subscribers of the original capital; but they were the real owners of the business, and those who had come in afterwards with their money were more in the nature of creditors whose interest in the business was defined by the arrangements which they had made with the original subscribers. The Directors were advised that legally the founders were, under the scheme, not entitled to anything, but, as he had already said, the desire of the Board had been to prepare a scheme which should be as equitable as possible, and if they approved of the founders being placed upon the same footing as the ordinary shareholders, they could carry out the arrangement in giving them £4 in ordinary shares in respect of each founder's share. That gave the founders an advantage, because at present they were not entitled to anything until the ordinary shareholders had received 10 per cent., whereas, under the new arrangement, they would at once rank with the shareholders, although only for a small amount; on the other hand, it was of great advantage that the founders' shares should be abolished. It would be seen from the schedule that the new capital was there put at £519,260, but the whole of this might not be issued at once. He had already referred to the £24,000 first mortgage debentures and to the £50,000 second mortgage debentures, and, in respect to the last item, there were 10,000 ordinary shares, representing £20,000, for which the scheme must provide, in case they should have to be exchanged for the £50,000 income bonds attached to the second mortgage debentures. Then it must be remembered that the second mortgage debentures were being reduced by half yearly drawings, and the first drawing had already taken place, and £2,000 had been paid off. Thus the capital of the new company would not be so large as appeared in the schedule, but, of course, the scheme must provide for every existing contingent or pos-

sible claim. The nominal capital would be £400,000, of which £300,000 would be in ordinary shares and £100,000 in preference shares, but as the ordinary shares to be issued would be at the outside £240,000, there would be a surplus of £60,000, and perhaps £80,000 of ordinary capital available for issue. Then of the preference share capital there would be available for future issue upwards of £70,000. Of course the desire of the Board was to keep the capital down as low as possible. Although the measures proposed were drastic, they were wise, and such as prudent men of business ought to face. At present the shares were at a heavy discount in the market, and the Company was suffering in name and credit. That was all by reason of the disrepute into which the Company had fallen in consequence of its late unfortunate associations. He asked them to put an end to all that, and let the Company turn its back upon the past and go forward and compete with others, and share with others upon equal terms the work which lay before them. He then referred in general terms to what had led up to the loss of capital. He was not going to commit himself to any definite promises as to the dividends they would be able to pay. No one could be absolutely sure of the future, but he did not mind promising them one thing on behalf of the Board and of the staff and that was that they would spare no efforts to keep down expenses, to increase the volume of profitable business, and to raise in every way the name and credit of the Company. There were some legal reasons why the reconstruction must be carried out if they wanted to receive dividends in future; but he would not trouble them with a statement of those. It did not affect their pockets at all, whether they received 6 per cent. on a share having a face value of £10, or 12 per cent. on a share having a face value of £5, but it would improve their position very much if, as a result of the reconstruction, the market value of the shares improved. Before concluding he referred to a matter which afforded him some satisfaction. That was that the technical work of the Corporation had invariably been carried out with entire satisfaction to their customers, as, for instance, at Liverpool and the electric tramways in South Staffordshire. In the case of machines recently supplied to an important corporation they were entitled to a handsome bonus, because the machines proved more efficient than was specified. He could multiply instances of that kind. He then seconded the resolution proposed by the Chairman.

After some discussion all the resolutions given in our last issue were put to the meeting and unanimously carried.

A vote of thanks to the Chairman brought the proceedings to a close.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY, LIMITED.

The half yearly general meeting of this Company was held on Wednesday at the Cannon-street Hotel, E.C., to obtain the sanction of the shareholders to the payment of an interim dividend of 5 per cent., or 10s. per share, free of income tax. Mr W. S. Silver (chairman) presided.

The Secretary (Mr. William J. Tyler) having read the notice convening the meeting,

The **Chairman**, in moving the adoption of the motion, said: We are very glad to see you. You may perhaps remember on the last occasion I referred to a cable that we had just manufactured, between 2,000 and 3,000 miles, which we were about then to lay in the Pacific. That work has been completed and paid for. Referring to it, I believe I am justified in saying that it is one of the best cables that we have made. In reference to trade generally I am very glad to say that the returns are equal to previous years—somewhat in excess. I do not know that I can add to these remarks. I will ask my friend, the managing director, to give you a report of the French works, to which he has just paid a visit, and will conclude by moving that a dividend of 5 per cent., or 10s. per share free of income tax, payable on 6th inst., be now declared.

Mr A. Scott seconded the motion, which was unanimously adopted.

Mr Matthew Gray (managing director) stated: As the chairman has just said, I have been visiting our French works recently within the last few weeks, and I am glad to report that everything is going on there satisfactorily. We have a very nice little works there, and are doing very good work, and I think we are doing it on a proper basis and one that will give a moderate return for our exertions. I do not think that the shareholders need be at all anxious about the French works. I think they are in a very good position, and likely to be satisfactorily managed. I do not know that I have anything else to say as far as the French works are concerned. I regret to tell you that one of our agents for Ireland has died during the last month, a man who had been with us for 19 years, a very worthy, decent fellow he was, but he died about three weeks ago of heart disease. I went over to Ireland about 10 days ago for the purpose of making arrangements for carrying on our Irish business, and I have just returned. I think I have made such arrangements as will prove satisfactory. Although I must express my sincere regret for the loss of our worthy agent, still I think under the circumstances probably it will turn out not so injurious as we might have expected. I think the arrangements now made are such as will enable us to carry on our Irish business in as satisfactory a manner as hitherto. I do not think I have anything else to say. The works at Silvertown are in a satisfactory condition, and everything is going on in the usual manner and I think satisfactorily. I think we could do more cable work if we had it to do.

Mr Martindale proposed, and **Mr. Treble** seconded, a vote of thanks to the Directors and others connected with the business, this concluding the proceedings.

EDINBURGH ELECTRIC SUPPLY CORPORATION.

A special meeting of the Edinburgh Electric Supply Corporation, Limited, was held in Edinburgh on the 28th ult. for the purpose of considering a resolution for voluntarily winding up the Company under the provisions of the Companies' Acts. Mr Walter Berry (chairman of the Company) presided, and there was an attendance of about twenty gentlemen.

The **Chairman** made a few remarks regarding the initiation of the Corporation, which was registered on April 14, 1890, the shareholders being nearly all Edinburgh citizens. The Directors had had every reason to expect that the Town Council would entrust that company with the work of lighting the city, but a majority of the Council had overruled the opinions of representative citizens. The romance of the shareholders was now ended. The Town Council had taken away their bride, and now that they were married he hoped they would live together happily ever afterwards, and that the progeny would not be too troublesome or contentious, or involve loss to the ratepayers. He most sincerely trusted that the Council would carry on the business to their own and to the citizens' satisfaction. He had no hesitation in asserting that had the authorities decided to entrust the electric lighting of the city to the Company, the result would have been satisfactory to the shareholders, the community, and to the honour of Edinburgh. He concluded by formally moving the resolution that the Company should be voluntarily wound up.

Sir Thomas Clark, in seconding the resolution, said although the Company was not to go on, he was very glad the Town Council had taken up the work, and he hoped they would meet with every success.

The resolution was unanimously agreed to.

Mr. F. T. R. Deas, in acknowledging the resolution on behalf of himself and his colleagues, said the guarantors of the preliminary expenses were the seven directors and Mr. John H. Robertson, stockbroker, and although the officials had tried hard to keep down the expenses still they amounted to a very considerable sum, and they had been paid up by the gentlemen mentioned without a murmur. Not only so, but the guarantors stood to lose a very much larger amount had occasion demanded, and he was sure the shareholders would fully recognise that their scheme could never have reached the important position to which it attained had it not been for the financial support of the guarantors.

On the motion of **Mr. J. H. Balfour, W.S.**, a vote of thanks was passed to the Directors and the Chairman for their services, and the meeting terminated.

UNITED RIVER PLATE TELEPHONE COMPANY.

The seventh annual general meeting of the shareholders of the United River Plate Telephone Company, Limited, was held on Tuesday at Winchester House, Old Broad-street, E.C.

Mr J. Irving Courtenay presided, and, in moving the adoption of the report, said the opinion he expressed last year, to the effect that they had seen the worst of the trouble in the Argentine Republic, had come to pass. There had been from time to time periods of depression and of uncertainty, but the net results had been satisfactory. The average of the premium on gold in the year under review had been 215 as contrasted with 280 in the year before. The receipts of the Company had increased during the year from £98,699, at par of exchange—the amount received during the previous year—to £115,341. The expenses were slightly smaller, and, as they were now at a minimum, an increase must be expected as the business grew. The number of subscribers had increased by 710 during the year, against a loss of 125 in 1891-92. The working of the year showed a profit of a little over £7,000, but the policy of the Board was to consolidate and strengthen the position of the Company, and to that end they had dealt with the sum in a manner which, he hoped, would meet with the shareholders' approval. They had written off the balance of the taxes suspense account, £768, and £2,728 in respect of bad debts. They had also transferred £3,000 to the depreciation and renewal fund, and there still remained a balance of £540 to be carried forward. Notwithstanding the fall in the gold premium, the loss in exchange was greater than in the previous year, the explanation being that as the net receipts in the River Plate, at par of exchange, were nearly 50 per cent. more, the loss in conversion, notwithstanding the lower gold premium, was considerably larger. The loan from the bankers of £2,100, which appeared in the previous balance-sheet, had been paid off. They had just paid off the holders of the balance of the 7 per cent. debentures, who declined to convert into 5 per cent. debenture stock.

Mr. F. W. Jones seconded the motion, which was adopted.

Birmingham.—A meeting of the City Council was held on Tuesday, the Mayor (Hon. P. Allsopp, M.P.) presiding. The Mayor stated, on behalf of the Watch Committee, that the tenders for erecting the electric light station at Powick exceeded their anticipations, and they thought it desirable there should be some delay before recommending any action. He then moved a resolution to obtain a report on the cost of making navigable the River Teme. Mr Chamberlain Millington moved an amendment that the committee should be instructed to report on the cost of an alternative scheme of a steam generating station in the city. Both resolution and amendment were withdrawn—conditionally that the committee would report on the relative cost of a water power scheme at Powick and steam power in the city—until definite proposals were brought forward.

BUSINESS NOTES.

Sheffield.—The new post office at Sheffield is lighted throughout with 250 electric lights.

Richmond.—Work is being actively pushed forward in main-laying at Richmond, Surrey.

Great Northern Telegraph Company.—The receipts for the month of June amounted to £24,800.

Western and Brazilian Telegraph Company.—The receipts for the week ended June 30 were £2,369.

Ostend.—Tenders will be received by the municipality of Ostend for electric lighting to September 15.

Direct Spanish Telegraph Company.—The receipts for the month of June were £236 less than for the corresponding period.

Cuba Submarine Telegraph Company.—The receipts for the month of June were £220 less than for the corresponding period.

West India and Panama Telegraph Company.—The receipts for the two weeks ended June 30 were £96 more than for the corresponding period.

Dunfermline.—Messrs. R. E. Walker, Reid, and Co., manufacturers, Albany Works, are having the electric light introduced into their works.

Eastern Extension Telegraph Company.—The receipts for the month of June show an increase of £3,705 as compared with the corresponding period.

City and South London Railway Company.—The receipts for the week ending July 2 were £811, against £763 for the same period last year, or an increase of £48. The total receipts for 1893 show an increase of £1,715 over those for the corresponding period of 1892.

Kendal.—At a meeting of the Kendal Town Council last week, in the minutes of the Town Hall Improvement Committee it was stated that as regards the question of lighting the improved Town Hall premises with electric light, the committee were not yet in a position to say anything definite.

Liege.—Six tenders were submitted for lighting Liege—from Messrs. Van Rysselberghe, Antwerp; Siemens and Halske; M. Pieper, Liege (three tenders); and M. Jaspar, of Liege. The tenders varied widely in amount—from £20,000 up to £50,000—and also in proposed tariff—from 5d. to 7d. per unit. The decision was adjourned.

Illuminations.—For the illuminations on July 6 Messrs. Rashleigh Phipps have some very unique ideas at the following places: Messrs. Mooney and Co., Strand; Messrs. Mooney and Co., 19, High Holborn; Messrs. Kirkman and Son, 12A, George street, Hanover square; Messrs. Peal and Co., 487, Oxford street; and their own premises.

Telephones for Leamington.—A telephone exchange has been established at Leamington. In future Leamington will be able to answer satisfactorily to the question, "Hullo! Are you there?" At the opening, telephones in the Mayor's parlour were placed in communication with the Savoy, the Shaftesbury, the Empire, and other places of amusement in London.

The Paragon.—The Paragon, Mile End road, is now closed for alterations, and Messrs. Vaughan and Brown, 15, 16, and 17, Kirby street, E.C., are laying down specially designed electrical plant for generating the electric current, and also installing the whole of the building with massive electroliers and brackets. They are also laying down a specially arranged heating apparatus for warming the building.

City of London Electric Lighting Company.—The Directors of this Company have declared an interim dividend of 5s. 4d. per £10 share, less income tax, on the first issue of 20,000 cumulative 6 per cent. preference shares, Nos. 1 to 20,000 inclusive. The payment is calculated at the rate of 6 per cent. per annum on the respective instalments for the period ended June 30, 1893, and is payable on July 11 next.

Sutton (Surrey).—With regard to the scheme of electric lighting for Sutton, the General Purposes Committee proposed at the last meeting of the Sutton Local Board, that Mr. Segundo and Messrs. Girdlestone, Tatham, and Co. should be requested to report on the whole question. The matter was discussed at some length, and Mr. Wellington, as chairman of the committee, moved the adoption of the report. Mr. Hay seconded the motion, which was agreed to.

Proposed Extension at Bradford.—Mr. J. N. Shoolbred and Mr. S. W. Baynes, of the Bradford Corporation Electricity Supply Works, had an interview last week with Lord Kelvin on the subject of the method to be adopted to extend the electricity supply in Bradford. Lord Kelvin will present his report to the Electricity Supply Committee in due course, and the committee will then determine whether it is necessary to invite Lord Kelvin to explain his views on the matter in person.

Eastern Telegraph Company.—The accounts of this Company show, after placing about £88,000 to reserve fund, a balance available sufficient to pay the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the preference shares, less income tax, and a final payment of 2s. 6d. per share, with a bonus of 3s. per share, both tax free, on the ordinary shares, making with previous payments on account a total distribution of 6½ per cent. on those shares for the year ended March 31, 1893.

Electricity Supply Company for Spain.—The Directors of this Company invite tenders for the supply and erection of certain machinery, etc., for the extension of their electricity works in Madrid. Plan of buildings and statement of requirements, with terms and conditions of tender, may be obtained at the offices of the Company, 15, St. Helen's-place, London, E.C., on and after Monday next on payment of one guinea. Sealed tenders must be sent to Mr. P. A. Latham, secretary, by 11 a.m. on July 29.

Lancaster.—Major General Crozier, R.E., held a Local Government Board enquiry, last week, into an application made by the Town Council for sanction to borrow £25,000, the estimated cost of a system of electric lighting installation for the borough, to be provided by the Brush Electrical Engineering Company, of London. For the present the Corporation propose to light only the main streets in the centre of the town, but arrangements are being made so that additional plant may be put down as required.

Chelmsford.—Messrs. Deacon, Gibson, and Medcalf, the solicitors to Messrs. Crompton and Co., have written giving the Council notice of their intention to apply to Parliament for a provisional order under the Electric Lighting Acts for statutory powers within the borough. At the Town Council meeting, in reply to Alderman Durrant, the Town Clerk, said that powers under a provisional order were rather more extended than those under the license Messrs. Crompton now held. The letter was referred to the Lighting Committee.

The Gilgit Telegraph.—It is a matter for regret, says the *Indian Engineer*, that no commencement has been made on a telegraph line up the Khagan Valley. It is impossible to believe that the Government will not adopt this route as the permanent one, giving direct communication with Gilgit by way of Chilas, and it is difficult to understand why any delay occurs in coming to a decision on the subject. Several lakhs of rupees would be saved yearly, moreover, in provisioning the Gilgit garrison if the road over the Babusar Pass were to be made.

St. Pancras.—The Electricity Committee reported at the St. Pancras Vestry meeting that they had received an application from Messrs. Gilbey, wine merchants, Chalk Farm, to supply their premises with electric lighting. They would require 400 lights, and would enter into an agreement to consume for three years. Applications for electric lighting for districts near Regent's Park had also come in. The cost of laying the service would be about £2,650, but the annual income would be about £250. It was agreed that the committee at once proceed with the work.

National Telephone.—The Directors of the National Telephone Company, Limited, have resolved to recommend the following dividends, less income tax, for the last half of the financial year ending April 30 last: At the rate of 6 per cent. per annum on the amounts paid up on the first and second preference shares; at the rate of 5 per cent. per annum on the amounts paid up on the third preference shares; at the rate of 5 per cent. per annum on the amounts paid up on the ordinary shares, making, with the interim dividend already paid, 5 per cent. for the year, leaving a balance of about £32,000.

Madrid Tramways.—The Spanish correspondent of *Industries* states that a scheme has been presented to the different horse-tramway companies in Madrid to convert them all into electric tramways and work them for a period of 25 years at 3½d. per kilometre run (5½d. per mile), the plant and cars at the expiration of the concession to belong to the tramway companies. Capital to the extent of £400,000 will be required, which is expected to be raised in Germany. So far, it is stated, the tramway companies are reluctant to accept the proposal for several reasons, but in the end it will probably be carried out.

Barnsley.—If something is not done at once for the electric light at Barnsley the chance will be gone for some years. At the discussion of the renewal of the gas contract, Mr. Hawke raised the question of electric light, and said he thought they were to hear from Mr. Hammond as to a lecture as an advertisement for electricity. The Chairman said the Board did not see paying the expenses of a lecture for someone else to reap the benefit. He thought they were getting on amicably at present. The Gas and Lighting Committee, we understand, are to meet and consider the proposal, and if anyone wishes to put in particulars as to cost of electric lighting, then will be evidently the time.

Wigan.—At a special meeting of the Wigan Gas Committee last week, a letter was considered from the Corlett Electrical Engineering Company asking the Corporation to allow them to supply current to the new Royal and Ship Hotels, the new Mineral Waterworks, and the block of buildings to be erected in Millgate by Sir F. S. Powell, M.P. Mr. Corlett attended, and stated that he had been asked to tender for the supply of electric current to the places mentioned. He discussed the terms on which the company would cease to supply the electric current in case the Corporation decided at some future time to supply electricity themselves. Mr. Corlett was requested to submit the terms in writing.

Russian Tunnel.—While several subterranean railway tunnels of the most approved design are in process of planning or construction in London, we must look to Russia for something entirely novel in this respect, says the *Mining Journal*. A proposal has been laid before the Public Works Department at St. Petersburg to pierce under the Neva in the shape of a circular tunnel having a diameter of 43ft. The peculiarity of the subway design is in the provision of four floors or decks for pedestrians, vehicles, trams, and telegraphic cables respectively. Details as to the approaches are not to hand, but the cost of the tunnel construction is given at £400,000. It is not at all improbable that we shall hear more of "decked" tunnels, for subterranean work has come much to the front of late. In connection with the proposal under notice, it is remarkable that some of the greatest engineering schemes in this hemisphere are in progress, or on paper, in the Czar's dominions.

Rashleigh Phipps.—On Saturday, the 1st inst., the employes of Messrs. Rashleigh Phipps and Co., 102, Oxford-street, held their annual holiday at Brighton. The party proceeded by an early train, and after a couple of hours, spent either in or upon the sea, sat down to an excellent dinner, to which good justice was done. It is worthy of remark that excepting where business intervened there was no single absentee, every available man being present. After dinner the party proceeded by brake to Shoreham, and thence to Southwick, where an enjoyable cricket match was played on the village green. The proceedings throughout were carried on with marked enthusiasm, and the measure of success of the whole outing was such as is seldom attained on these occasions. This firm has since Mr Phipps dissolved partnership in November last carried out 65 installations (list of which we hold), and these installations, totalled up, run into 3,949 lights (private houses 1,378, business houses 2,000, temporary lighting 571 lights).

The National Transformer System.—Messrs. Shippey Bros., Limited, announce that they have been appointed sole European agents for the National Electric Manufacturing Company, of U.S.A., and send us illustrated catalogues of the various descriptions of electrical plant manufactured by the company, which includes alternating and direct current dynamos, electric motors, generators, ventilators, transformers, incandescent lamps, switch boards, and various other appliances. The National system appears to be very popular in the United States, and are apparently doing a very large business, as from list of complete installations carried out by the company up to January last, the work exceeded 200,000 lamps and over 1,000 h.p. in motors and generators. This large amount of work speaks well for the system, which is making rapid strides in America. The new multipolar generator manufactured by the National Company has several interesting features. We learn that Messrs. Shippey Bros. are making arrangements for holding stock in England for the leading types of machines for prompt delivery.

York.—At the meeting of the York City Council the town clerk reported that the Bill confirming the provisional order for the extension of the city, after passing through the House of Commons, had been read a first time in the House of Lords. The Electric Lighting Sub-Committee reported that after consideration of the report submitted to them by Prof. Kennedy, F.R.S., they had decided to recommended the committee to ask for the authority of the Council to accept the tender of Messrs. Siemens Bros. and Co. for the lighting of the city. Prof. Kennedy attended the meeting of the committee, and after the discussion of the recommendation of the sub-committee, it was resolved that the consideration of the recommendation be deferred until the whole committee has had an opportunity of considering an abstract of the reports submitted by Prof. Kennedy, such abstract to summarise the tenders of the following firms: Messrs. Crompton and Co., Limited; Messrs. Siemens Bros. and Co., Limited; Messrs. C. A. Parsons and Co.; and the Brush Electrical Engineering Company; and to contain a statement showing the comparative cost of production in each tender in the area first proposed to be lighted, and in the proposed extension of such area together with the amount required to pay interest and provide the sinking fund in connection with the capital outlay.

Blackpool.—The slow progress of the electric installation at Blackpool is causing fears that the lighting will not be ready when promised. "We understand," says the *Blackpool Gazette*, "that at a recent meeting the Highway Committee of the Corporation had under serious consideration the want of unanimity between the highway, gas, and electric lighting departments which has latterly been conspicuously evident. On several occasions lately the ratepayers have been treated to the edifying spectacle of footpaths and roads being remade and left in splendid condition one week, only to be uprooted for gas or electric lighting purposes a week or two following, and left in a disorder almost amounting to danger. These three important departments have obviously been working without prearrangement or consultation. One week a footpath might be pulled up to lay gas pipes, while the next week another section may be excavated to put down the electric lighting wires. If the departments had been working in harmony, as they ought to have been, a considerable amount of money would have been saved the ratepayers during the last six months alone. After considering this question, we understand the Highway Committee passed a comprehensive resolution insisting upon the necessity of the several departments working more in unison than has latterly been the case. The ratepayers will be glad to hear this fact, and they will hope to see a change for the better in this respect in the future."

The Scarborough Electric Station Chimney.—The works of the Scarborough Electric Lighting Company in Seamer-road are progressing satisfactorily, though there was at one time a fear that their completion would be delayed by an untoward incident. The most prominent feature of the works is a chimney of large proportions, which is some 130ft. high, for the boiler fires. It is built upon a solid block of concrete of 20ft. cubical section, upon a bed of clay. When nearly the maximum height, it was found a few weeks ago that a settling had occurred over the crown of the arch of the flue. This did not amount, at the point at which it occurred, to more than 2in., though it threw the shaft out of the plumb some 18in. at the top. Work was at once stopped in the structure, and experts were called in to give their advice. They reported that the chimney could be straightened by cutting the courses on the side opposite to that on which the settlement occurred. A meeting of the directors of the company was held, and the report of the experts was considered. They recommended the cutting of the courses, and the strengthening and buttressing of the chimney. In a discussion afterwards held, it was stated that in most cases of falls of chimney shafts the courses had previously been cut in order to straighten them. It was felt that it would be better to run no risks, and it was ultimately decided to pull the chimney partly down, and rebuild it again. It is satisfactory to learn that the incident will in no way delay the turning on of the light in Scarborough as the new shaft can be completed in time. Other work is forward, that of laying the main conduits in the compulsory area is now very nearly completed and in a few days the threading of the cables may be expected to commence. Wires are already laid through the pipes in order to facilitate this work.

Manchester Corporation Electric Lighting.—The Electric Lighting Department of the Manchester Corporation Gas Committee has prepared a report for the year ended March 31 last, for presentation to the City Council. The report, which is signed by Alderman Sir J. J. Harwood, chairman of the Electric Lighting Department, and Mr. Joseph Brooks, chairman of the Gas Committee, says: "The buildings at the electric lighting station, Dickinson street, for the accommodation of the engines, dynamos, boilers, etc., are now completed, and the following plant has been fixed in position—viz., six steel boilers, 8ft. by 30ft., steel tank, coaling stage, and crane, steam pipes, six 90 h.p. compound vertical engines, two 360-h.p. compound vertical engines, six dynamos (102 volts), two dynamos (410 volts), and two travelling cranes. The switch and instrument boards are in course of erection. With regard to the main conductors in the streets, one mile 100 yards of concrete culvert have been constructed, and about 65¼ tons of copper strip placed therein upon porcelain insulators. Two and a half miles of cast iron pipes have been laid, into which six miles of ⅝in. and five miles of ½in. insulated cable have been drawn. The works are rapidly approaching completion, and it is anticipated that current will be ready for consumers by the 1st August next." An abstract of accounts, attached to the report, shows that the amount sanctioned for the purposes of the Corporation Electric Lighting Order, 1890, was £80,000, and that of this sum £50,200 has been borrowed, £10,000 at 3 per cent. and £40,200 at 3½ per cent., leaving £29,800 sanctioned but not borrowed. The items of the total expenditure to March 31 are: Land, including law charges incidental to acquisition (on account), £2,161. 12s. 3d.; buildings, £9,337. 14s. 3d.; machinery, £13,196. 4s.; mains, £14,077. 1s. 11d.; electrical instruments, £41. 11s. 9d.; expenses prior to generating of electricity, £2,906. 6s. 10d.; making a total of £41,720. 10s. 8d., and leaving to balance of capital account, £8,479. 9s. 4d.

New Issue.—The Yorkshire House-to-House Electricity Company have a total authorised capital of £100,000, and have issued 7,366 shares of £5 each; 2,634 shares are now offered to the present shareholders for subscription. The money is wanted for the extension of works, and applications should reach the company's bankers on or before Monday, the 10th July. The following circular has been sent to the shareholders: "The directors have pleasure in reporting that the demand in Leeds for the electric light is so heavy as to make an immediate addition to the company's plant necessary, and they have therefore decided to offer for subscription the balance unallotted of the issue of 10,000 ordinary shares of £5 each—viz., 2,634 shares. The works have been so constructed that additions can be easily provided at a comparatively small outlay. The addition to the plant now proposed consists of a 200 i.h.p. engine, and dynamo to correspond, which will raise its capacity from 250 to 350 kilowatts, being an increase of 40 per cent., though at an increased expenditure of capital of less than 10 per cent. The importance of providing sufficient plant to enable the company to deal with all the business presented to it hardly needs enforcing; and the profit-earning capacity of the works may be expected to increase in even greater proportion than the output, as the cost of each unit of electricity supplied will naturally decrease with the increased production. The directors consider that the success already attained justifies them in regarding the company's shares as a safe and profitable investment, and they think it right to give the present shareholders the preference of subscribing the additional capital now required. It is proposed to call up 10s. per share on application and 10s. on allotment, and to make no further call on the shares now offered for subscription during the present year. The directors, who already hold more than one-fifth of the subscribed capital, propose to apply for an additional amount of not less than £3,000. If more than 2,634 shares are applied for, allotments will be made in proportion to the present holdings of the applicants. Copies of the original prospectus, and forms of application, may be obtained from the secretary. The contracts and documents referred to in the prospectus may be inspected at the offices of the company; and applicants for shares will be considered to have notice of any other contracts, and to have waived further compliance with Section 38 of the Companies Act, 1867; and allotments will only be made on this footing. Applications for shares should be made on the enclosed form, and sent with the deposit of 10s. per share to the company's bankers, Messrs. W. Wms. Brown and Co., Commercial-street, Leeds, on or before Monday, July 10."

Laying the Memorial-Stone at Cardiff.—An important step in the installation of the electric light in Cardiff by the Corporation was taken on Monday afternoon, when the Mayor laid the memorial-stone of the central station at which will be generated the supply. The station is in course of erection on Canton Common, near the Great Western Railway. In the form which is immediately contemplated, the site will be about 80ft. square. This, while amply sufficient for plant to supply current to the compulsory area in the centre and principal business part of the town, provides also, both as to site and the character of the buildings, for extensions being made from time to time with ease and economy. The cost of the

present portion of the scheme is £32,500, which includes the cost of a chimney 150ft. high—a structure, the extent and capacity of which is expected to meet present and future requirements. The buildings for which tenders have been let, and foundations already laid, will comprise engine and boiler houses, coal stores, etc., and there will be a private siding parallel to the existing sidings of the Great Western to the main line. It is proposed to lay 3in. cast iron pipes from the supply station to the compulsory area, and these, it is expected, will be sufficient to take cables for the whole of Cardiff being illuminated with the electric light, so that the taking up of the streets will be minimised. The first thing which it is proposed to do is to light the streets in the area indicated by means of 44 arc lamps. This will be brought about within the next three months, and by Christmas the Corporation will be able to supply every possible consumer within the district. The arc lights will be 22ft. above the street level, and wherever it is possible to do so they will be placed in the centre of the road. In selecting the site which was eventually fixed upon, the Electric Lighting Committee found that the utilisation of land already in possession of the Corporation would more than compensate for the extra length of cables to be laid connecting the town with the central station. In this respect they profited by the experience of Bournemouth, where the electrical supply station is nearly two miles out of the town. The stone-laying ceremony was performed in the presence of a goodly company, including the deputy mayor (Alderman Daniel Lewis, J.P.), and a full attendance of aldermen and councillors, the town clerk (Mr. J. L. Wheatley), the deputy town clerk (Mr. F. C. Lloyd), the borough engineer (Mr. W. Harpur), the electrical consulting engineer (Mr. W. H. Massey), and others. Before laying the stone, the Mayor gave a brief outline of the history of electric lighting in Cardiff, and having accepted a silver trowel and mallet at the hands of the borough engineer and Mr. Thomas (contractor), his worship placed in position the slab, which bears this inscription: "This memorial stone was laid by the Right Worshipful the Mayor of Cardiff, Councillor William Edward Vaughan, J.P., chairman of the Lighting and Electrical Committee of the Cardiff Corporation, on the 3rd day of July, 1893.—JOSEPH LARKE WHEATLEY, Esq. (town clerk); WILLIAM HARPUR, M.Inst.C.E., and WILLIAM H. MASSEY, M.Inst.C.E. (joint engineers); W. THOMAS AND CO. (contractors)." A cordial vote of thanks was passed to the Mayor, on the motion of Alderman D. Lewis (deputy mayor), seconded by Councillor Gerhold. The party having returned to town, they were entertained to luncheon in the Assembly room, Town Hall, by the Mayor. A number of toasts were honoured, amongst others being that of "Success to the Electric Light of Cardiff and the Mayor and Corporation." This was proposed by Mr. Lascelles Carr, who urged the importance of the Corporation having in their hands such undertakings as the lighting of the town and the waterworks, thus securing the control of their own streets. In responding to the toast, the Mayor said the town had suffered long enough by private companies possessing monopolies. Alderman Carey also responded, and prophesied a big future for the electric light in Cardiff. The toast was also spoken to by Alderman Thomas Rees, who was interestingly reminiscent as to the artificial lighting of the borough and its development. The remaining toasts were "The Architect and the Electrical Engineer," acknowledged by the borough engineer (Mr. W. Harpur) and Mr. W. H. Massey, and "The Builders and Contractors," replied to by Mr. Thomas and Mr. Chubb.

PROVISIONAL PATENTS, 1893.

JUNE 26.

12490. **Improvements in the means of conveying or administering electricity for medical purposes or others.** Edmond Savary d'Odiardi and Eva Savary d'Odiardi, 43, Cornwall gardens, London.

12491. **Improvements for administering electricity to animals or human beings.** Edmond Savary d'Odiardi and Eva Savary d'Odiardi, 43, Cornwall gardens, London.

12492. **Improvements in liquid electrodes.** Edmond Savary d'Odiardi and Eva Savary d'Odiardi, 43, Cornwall gardens, London.

12793. **Improvements for charging vapours for inhaling purposes or others with electricity.** Edmond Savary d'Odiardi and Eva Savary d'Odiardi, 43, Cornwall gardens, London.

12507. **Improvements in the construction of galvanic cells.** Cæsar Vogt, 38, Chancery lane, London.

12514. **Improvements in safety fenders or lifeguards for electric street railway carriage and other vehicles.** Edwin Rochester, 45, Southampton buildings, Chancery lane, London. (Complete specification.)

12516. **An improved loud-speaking telephone and circuits for same.** Alfred Graham, 1, Gresham buildings, Guildhall, London.

JUNE 27.

12577. **Underground electric system.** John Alexander Kennedy McGregor, 43, Lincoln's-inn-fields, London. (Complete specification.)

12612. **Improvements in the construction of electric fittings.** Edward Priddle, Newington Priddle, and Co., Limited, 1, Queen Victoria-street, London.

12625. **Improvements in and connected with the purification of sewage by electrolysis, producing electricity as a by-product.** Walter Walker, 34, Lorne-gardens, London. (Complete specification.)

JUNE 28.

12662. **Improvements in electrolysis.** Emile Andreoli, 18, Somerleyton road, Brixton, London. (Complete specification.)

12700. **An improved electric push or contact-maker.** Robert Beveridge, 18, Buckingham street, Strand, London.

12702. **Improvements in electric cables.** George Cotton Melhuish Hardingham, 191, Fleet street, London. (The firm of Felten and Guilleaume, Germany.)

JUNE 29.

12785. **Improvements in switches for electric currents.** Anthony George New and Arthur James Mayne, 12, Palace-chambers, Westminster, London.

12786. **Improvements in self-regulating mechanisms for electric arc lamps.** Anthony George New and Arthur James Mayne, 12, Palace-chambers, Westminster, London.

12787. **Improvements in the manufacture of coke or carbon for electrical purposes.** John Laskey Dobell, Charles Percy Shrewsbury, Frank Lawrence Marshall, and John Cooper, 57, Chancery lane, London.

JUNE 30.

12806. **Improvements in electrical switches.** Frederick Adolf Timm, 18, Fulham place, Paddington, London. (Complete specification.)

12850. **A counter of electricity.** Francois Alexandre Brocq, 28, Southampton buildings, Chancery lane, London.

12852. **Improvements in or relating to the distribution and supply of energy in electric current circuits.** William Lowrie, 433, Strand, London.

12857. **Improvements in and connected with tanks for the electrical decomposition of chloride of sodium or potassium in solution.** James Charles Richardson, 6, Bream's-buildings, London.

12864. **Improvements in electric locomotives and vehicles.** Joseph Frederick Wilks Featherstonhaugh, 46, Lincoln's-inn-fields, London.

12866. **An improved electric lighter.** Reginald Walter Barker, Monument chambers, King William street, London. (Max Sommer and Bernhard Troop, United States.)

12870. **Magnetic fastening for safety lamps and the like.** Heinrich Freise, 54, Fleet street, London. (Complete specification.)

JULY 1.

12919. **Electrical arc lamps.** William Jeffrey, 39, Beckton road, Barking road, London.

SPECIFICATIONS PUBLISHED.

1885.

12681. **Arc lamps.** Brockie and Pell. (Second edition.)

1891.

22304. **Electric signalling.** Thompson. (Second edition.)

1892.

10735. **Producing sodium, potassium, etc., by electrolysis.** Bull.

10873. **Electrical indicator apparatus.** McEvoy.

10876. **Reflecting and distributing electric light.** Timmis.

12382. **Making wire, etc., by electro-deposition.** Sanders.

12999. **Distributing electric currents.** Kapp.

14647. **Electromotors.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

1893.

6556. **Medical electrical instruments.** Lake. (Boyd's Medico-Electrical Vitaliser Company.)

7424. **Electric arc lamps.** Waterhouse and others.

9295. **Electrolytic apparatus.** Craney.

9297. **Electrolytic apparatus.** Craney.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
City of London	—	11¾
— Pref.	—	12¾
Electric Construction	10	4
Gatti's	—	5¼
House-to-House	5	5¾
India Rubber, Gutta Percha & Telegraph Co.	10	23
Liverpool Electric Supply	5	6¼
	3	4¼
London Electric Supply	5	1
Metropolitan Electric Supply	—	6¾
National Telephone	5	5¼
St. James'	—	8¼
Swan United	3¾	3⅛
Westminster Electric	—	5¾

NOTES.

Technical School.—The foundation stone of the new technical school buildings at Darwen was laid last Saturday by Mr. C. P. Huntingdon, M.P.

Ostend.—Tenders are invited by the Administration Communale of Ostend for the lighting of the town by electricity. The adjudication will take place on September 15 next.

Cannes.—While Nice is to have a station shortly, Cannes has already obtained hers, and 7,000 lamps are glowing. In a couple of years the total number will rise, it is thought, to 20,000.

Paris.—The Parisian Compressed Air Company are intending to instal at the rue Saint-Roch an important central station, using the five-wire system in conjunction with Tudor accumulators.

"The Electrical Worker."—A copy has reached us of the *Electrical Worker*, published at St. Louis, the organ of the National Brotherhood of Electrical Workers of America. Says the prospectus: "It reaches the men who do the work."

Balloon-Lighting.—The balloon "Humboldt," which recently came to grief, has been replaced by another by the German Aerial Navigation Department. This balloon is electrically lighted at night, and experiments in electric signalling are about to be made on its journeys, commencing generally at 11 p.m.

Electrical Treatment of Stricture. — Mr. C. Mansell Moulin, surgeon to the London Hospital, has an article on the application of weak electric currents to the cure of stricture in the *Lancet* (8th inst.). He gives cases, and, although considering there is some field for electricity, is not very enthusiastic in its favour.

Appointment at Sheffield.—A teacher of mechanical and electrical engineering subjects, able to take charge of large classes in machine construction and drawing, practical plane and solid geometry, and to direct workshops in wood and metal, is wanted by the Sheffield School Board. The Board state their preference for a Whitworth scholar.

Water Power in Switzerland.—The Conseils Communaux of Locle and of Chaux de Fonds, Neuchâtel, Switzerland, have opened a competition for the utilisation of a part of the water power at Reusse. Particulars may be obtained of the Direction des Eaux et du Gaz, Chaux de Fonds, Switzerland, and tenders will be received until August 31.

"School of Magnetism."—The "Société Magnetique de France" (23, rue Saint-Merri) has organised a practical school of magnetism, with a two years' course under professors to study physiology, animal magnetism, occultism, hypnotism, and so forth. The first courses will be given by Drs. Vigouroux and Rouxel, with experimental clinical demonstrations.

Tax on Electricity.—A curious case has arisen at Vigan, France. M. Carrière there has a right to charge *octroi* on goods entering, and amongst other commodities are candles and petroleum. Now electricity is installed in the town, however, his receipts on this score are diminished, and on plaint he has actually been awarded 400f. damages to his interests. Another injustice to electric light!

Electric Light Lantern.—A convenient electric light lantern (made by Colt, Beekman street, New York) is illustrated in the *Scientific American*, June 17. It has bellows, front and objective support that are removable, allowing the use of microscope or other scientific instrument. The adjustment of the carbons is very easy—no more difficult than the occasional turning of the lime in ordinary lanterns.

Altona.—The *Elektrotechnische Zeitschrift* for July 7 contains a well-illustrated long descriptive article, by Herr Uppenborn, on the lighting of Altona by Messrs. Schuckert. The plans, details, and views give a good idea of the best modern continental practice in central station work. The system is direct current with accumulators.

Electricity in Quarrying.—At the quarries of the Société Anonyme des Carrières du Hainaut at Soignies, Belgium, the Compagnie Continentale d'Electricité de Bruxelles has installed a generating dynamo, which operates two motors and lights 100 16-c.p. lamps and eight 12-ampere arc lamps. One of the motors drives the pumps, and the other actuates a windlass which is used for hauling the blocks out of the quarry.

The Single-Trolley System.—The single-trolley system has already made fair progress in Germany at Halle, Bremen, and Gera. A new line on the method has just been started at Remscheid, and work is rapidly being advanced at Essen. We have already referred to the decision to adopt this system in several French towns, and at the moment negotiations are proceeding for the establishment of a line at Etaples, in the Pas de Calais.

A Kindly Recognition.—We are informed that on the successful completion of the Royal Hotel installation, Mr. Collings, Messrs. Siemens Bros. and Co.'s engineer in charge of the works, was presented by Sir Polydore de Keyser with a handsome and costly gold non-magnetic watch. The value of this gift was greatly enhanced by the kindly words with which Sir Polydore accompanied the presentation. We think that an act so graceful is worthy of record.

Transforming Continuous to Alternating.—M. Felix Lucas (in *L'Electricien*, 8th inst.) describes at length, giving diagrams and sections, his apparatus for changing a continuous current, as from accumulators, into alternating currents of any desired frequency. A model machine has been made by MM. Sautter, Harlé, et Cie. A current of 1,000 amperes at 20,000 alternations per second, says the author, can be obtained with a wheel of one metre diameter with 20 brushes.

Nice.—The town of Nice is to be lighted electrically soon. At first it was thought to utilise the falls of Vesubia, but it is decided to have a steam station in the centre of the town. The Alsacian Society have the contract, but there are several large houses (a hint to the wise) who would nevertheless have their own installations if proper overtures were made. The three-wire system will be adopted. It would be interesting, by the way, to learn how far continental companies pay for their use of three-wire patent.

Friction Clutch.—A new elastic friction clutch, invented by M. Brancher, is illustrated in the *Revue Industrielle* (July 8). In this clutch the transmission from one shaft to another is effected by an elastic connection composed of bands of steel covered with leather, which make two and a half turns round a cylindrical drum. The connection is brought about by a cone under control of a hand-screw, and the second shaft takes up the rotation gradually from 0 to speeds of 100, 200, 500 revolutions. It has been applied to powers of 100 h.p., and has proved very practical.

Colliery Explosions.—At a general meeting of the South Wales Colliery Officials' Association, held at Pontypridd, last Saturday, under the presidency of Mr. Thomas, manager of the Ynyshir Colliery, a paper was read by Mr. W. Thomas, of the Ynyshir Collieries, suggesting means of avoiding suffocation in cases of fire in collieries. During the discussion Mr. Meredith mentioned an instance

where an electric signalling battery worked direct from the dynamo, and falling with some rubbish, caused a small fire in the colliery. The question will be further discussed at the next meeting.

"Commerce."—The somewhat humdrum official, not to say, dry *Chamber of Commerce Journal* becomes this week incorporated with *Commerce*, an illustrated weekly, price 6d. The size of *Truth*, with a coloured cover, full of interesting illustrations, an interview with Mr. Henry Norman, chatty articles, description of the Manchester Canal, not forgetting more serious financial and commercial articles and notes, the new journal makes a fair bid for success and brightness at a bound. The list of commercial situations vacant and wanted is continued. It is a paper to which those who deal with foreign countries should not hesitate to subscribe. It is published at Talbot House, Arundel-street.

Electrical Communication with Lighthouses.—The Royal Commission on Electrical Communication with Lighthouses and Lightships began on Tuesday their inspection of lighthouses and lightships on the south and east coasts of Ireland and the Isle of Man. They intend to visit Bangor, Belfast Lough, to-day, the 14th inst., after inspecting the South Rock and Skull Martin light vessels from H.M.S. "Enchantress," and they intend also to anchor in Lough Foyle on the 17th inst. for the purpose of visiting Rathlin Island, Innishowen, and the Inishtrahull lighthouses. Mr. Mulholland, M.P., who is a member of the Royal Commission, has paired with Mr. Munrow Ferguson, M.P., for the period of the cruise.

Electrolysis of Pipes.—Mr. C. H. Morse, inspector of wires at Cambridge, Mass., in a recent paper before the New England Waterworks Company, stated that in his town, after the electric street railway had been started, "lead pipes disappeared in a short space of time—some even in six to eight weeks." Rustless iron was tried, but it rusted away. The loss was not confined to pipes, but the railway company lost 25 out of their 500 volts. Where the volts and pipes got mixed, there was often little but mould left after a time. When they reversed the poles they hurt the gas company, and set up electrolytic action in the gas-pipes. Mr. Morse waxes very serious over the difficulty, and sees no way out but putting overhead returns.

Variable Meter.—An electric meter is described by the *Bulletin International*, which is arranged so that during one portion of the day it registers less than at others. This is to allow the use of current during the time of light load at less cost for motors and cooking. This result is obtained by allowing the registration of the meter to be affected, first by one train of wheels and then by another, the change being made by a wheel revolving once in 24 hours. The idea seems noteworthy, but it is doubtful if the Board of Trade would allow this false registration. The double-registration meter might register on two sets of dials for day and night service, the price to be lower in the former per supply unit. Companies on the look out for equalisation of load should look into this question.

Light and Frequency Phenomena.—Dr. Samuel Wilks has a letter in the *Lancet* (July 1) discussing Mr. Nikola Tesla's question as to whether it will ever be possible to analyse the condition of the retina when an image is evoked by thought or reflex action, so that a clear idea of its state might be obtained. "Although the direct influence of the nerve centres on the various tissues of the body must be admitted," says Dr. Wilks, "it is proceeding to a very great length to say with Mr. Tesla that the organs of the senses can be *affected* from within." This seems, he says, like a total contradiction of the teachings of physiology. "Mr. Tesla's suggestions," he adds, "are of great importance, but cannot be accepted, as they tend to break down our long-cherished views regarding our organisation and the operation of our senses."

Electric Light Accident at Rome.—On the Piazza Quirinal, in Rome, last Friday night, two electric light lampmen lost their lives through a piece of almost incredible carelessness. One of the large lamps opposite the palace suddenly went out. The lampman belonging to the district brought a ladder and ascended, but had scarcely touched the carbon when he fell to the ground from a height of 16ft. His companion, believing him to be seized with sudden illness, went up in his place, but almost immediately fell. Both men had neglected to use the simple mechanism at the base of the lamppost which interrupts the electric current when any repairs or manipulation are necessary. The men were conveyed to the hospital, but they were both dead. The engineer of the society states, says the *Standard* correspondent, that the orders given to the men as to the use of the switch are most rigorous, and the men are daily exercised in its use. The King telephoned to the hospital an enquiry about the unfortunate men.

Underground Telegraphs in Germany.—Soon after the great war of 1870 the military authorities decided on connecting the great fortresses of the empire by underground cables. The ease, says *Kuhlow*, with which the German lancers managed in France to destroy the enemy's telegraphic communications miles and miles ahead of the German vanguard was a lesson not to be forgotten at home; that very important instrument in modern warfare—the telegraph—was no longer to be entrusted to overground wires and poles at the mercy of any plucky horseman, but to a substantial cable sunk deep into the ground. In this way Metz and Strasburg became connected with each other first, and then with Mayence and Cologne, with Berlin and Graudenz at the other end of the empire. After the great fortresses there came the turn of the capitals, the seaports, and the most important commercial and industrial cities—all of which are now connected by subterranean cables, hid deep in the earth, or bedded in the solid rock, or resting on the bottom of rivers and lakes, well secured against the frequent interruptions by storms and floods and snows, to which overground lines are exposed.

Sir Francis Ronalds.—Honour to the pioneers in the vast field of science! says the *Daily News*. Mr. John Sime has just published at the Chiswick Press in pamphlet form a very interesting memoir of Sir Francis Ronalds, with autotype fac-simile of a portrait of this father of electric communication. Twenty years before Wheatstone and Cooke or Morse had patented their improvements in the telegraph, indeed while the first two were respectively lads of 12 and 14 years of age, Ronalds had sent messages over eight miles of overhead wires of his own construction, and had laid and worked a serviceable underground line of telegraph of sufficient length to demonstrate the practicability of communication by telegraph between long distances. Details of his overhead telegraph wires were published by him in 1823. Ronalds's residence at Hammersmith, where these experiments were carried out, is the house now, and for long past, occupied by Mr. William Morris, the poet, who has caused a tablet to be placed on the wall bearing the inscription, "The first electric telegraph, eight miles long, was constructed here in 1816 by Sir Francis Ronalds, F.R.S., etc."

Five-Wire Power Distribution.—MM. Zweifel and Hoffmann have elaborated for the town of Mulhouse (*Revue Industrielle*, July 1 and 8) a plan for distributing electric energy for motor purposes at 1,500 volts on the three and

five wire principle. Up to 50 h.p. the motors will be on the 750-volt branches, and above this on the 1,500-volt outside mains. Below 5 h.p. they can be on 110-volt lighting mains, which will be reduced by continuous-current transformers. With transformation the efficiency will be $\cdot 95 \times \cdot 95 \times \cdot 90 \times 80 = 65$ per cent., and without transformation (large motors) $\cdot 95 \times 95 \times \cdot 93 = 83 \cdot 9$ per cent. The following table is given :

Motors h.p.	Speed in revolutions.	Efficiency per cent.	Price (francs) per h.p. with accessories.
$2\frac{1}{2}$ to 5	1,500 to 1,000	80 to 83	500 to 350
5 to 25	1,000 to 750	83 to 90	350 to 150
25 to 50	750 to 600	90 to 92	150 to 120
50 to 100	600 to 450	92 to 93	120 to 110
100 to 250	450 to 250	93 to 94	110
250 to 500	250 to 100	94	110

The price will include foundations and leads ; the arrangements for excitation make the smaller sizes comparatively high.

Auto-Conduction.—M. d'Arsonval, at the Académie des Sciences, July 3, proposed a new method of electrification of the body, which he terms "auto-conduction." The currents which circulate in the body of a patient are not led to his person by conducting wires, but take place within the tissues themselves, which act as closed induction circuits. These currents may attain considerable strength as they produce no pain nor any conscious phenomena to the person experimented upon. They nevertheless act energetically on the vitality of the tissues. M. d'Arsonval obtains this result by placing the subject either entirely or in part within an oscillating magnetic field of very high frequency. Upon a cylinder of some insulating material is wound in one or two layers a carefully-insulated electric cable. This constitutes a kind of solenoid, within which the subject is placed ; it is traversed by the discharge of a condenser, arranged in a special manner, so that the coil is energised by a current of a frequency of 200,000. He bends the arm so as to form a circle, and closes the circuit while holding a lamp in his hand, which lights up without causing any sensation. This mode of electrification of the human body is stated to produce some curious effects.

University Laboratories.—The formal opening of the new laboratory of mechanical and electrical engineering at the College of Pennsylvania, is made the occasion of an illustrated article by Edward T. Child in the *Electrical World* descriptive of this laboratory. In the boiler-house are seven large boilers arranged for testing. It has a chimney 150ft. high, and a fan for forced draught. The laboratory proper is four storeys high of mill construction. On the first floor are engine and mechanical laboratories, with three 100-h.p. (Westinghouse, Armington-Sims, and Porter-Allen) engines driving Brush, Edison, and Thomson-Houston dynamos, and there are half-a-dozen other smaller engines. The second floor contains library, reading-rooms, classrooms, and testing laboratories. On the third floor are drawing-rooms, classrooms, and a more delicate electrical laboratory. The fourth floor contains blue-print and model rooms. Pattern-making is taught, and the installation makes a small central station in itself, while the real central station in the town is affiliated. Specialists give lectures on wiring, specifications, and business law. The whole thing, indeed, seems most thoroughly done for the turning out of well-trained practical electrical engineers.

Popular Electricity.—The *Glasgow Herald* concludes a useful series of five popular articles on "Electricity as an Illuminant" last Saturday. The last article deals with storage batteries, electrical units, and prices. The writer thinks the invention of an efficient arc light of much smaller candle-power than any now in use would be a most useful discovery. He should be recommended to try the "Midget" arc lamp, certainly one of the best of the smaller lamps. It burns well with five amperes at 35 volts, and could be run three in series on a 110 volt circuit. The writer concludes : "There is undoubtedly a great future for electricity as an illuminant. Men of the highest capacity are engaged in the industry. The past few years have shown that the quarterly bill for electricity need not exceed that for gas ; indeed as time goes on, and the new illuminant is in general use, its cost to the consumer will be decidedly less—a result the attainment of which will be greatly helped by the use of electric energy for purposes other than lighting, and at a time of the day when light is not in requisition. It is estimated that in London at the present time there are 800,000 incandescent lamps in use. But the best proof of the certain onward march of electricity as an illuminant is seen in the fact that wherever it is introduced the demands for its extension are continuous and ever increasing." Those who wish to have a full popular *résumé* of electric lighting for propagandist purposes might do worse than send round copies of these articles, which of course can be obtained at a penny per article.

Electricity in Mining.—Germany was, we believe, the first country in Europe to introduce electric power in mining operations, this being at Stassfurt salt mines several years ago ; but since then very little progress has been made there. At the Mining Exhibition, however, now being held at Gelsenkirchen—the centre of the Ruhr or Rhenish-Westphalian coal district—and where more than 200 firms are represented, electricity for lighting and motive-power purposes has been made to occupy a prominent position. Various dynamos are shown in operation by Schuckert and Co., of Nurnberg; and the Deutz Gas-Engine Works exhibit, among others, a 16 h.p. twin gas engine driving various motors of the General Electricity Company. The buildings are, of course, lighted by electricity, and from the machinery hall two installations of electrical transmission of power a distance of 330ft. are in operation : one is by Jorissen and Co., of Dusseldorf, with a Lahmeyer dynamo and motor, and the other by C. W. Hasenclever and Sons, of Dusseldorf, with Schuckert dynamo and motor. Ventilating fans are naturally in prominence, but there does not appear to be any application of electricity to pumping purposes. As regards miners' electric safety lamps, C. Pollak and Co., of Frankfort, the Accumulatorenfabrik Hagen, M. Vorster, of Jena, and F. Feldhaus, of Cologne, are the exhibitors. Wire ropes and cables are ably represented by Messrs. Felten and Guilleaume, of Mulheim-on-the-Rhine, Becker and Co., of Schalke, H. Grillo, of Dusseldorf, and H. Puth, of Blankenstein. In the grounds, a mining electric locomotive by Schuckert and Co. hauls two waggons.

Municipal Telephones for Glasgow.—The following memorandum drawn up by Council or Starke was submitted to the Special Committee of the Glasgow Town Council on Monday : "A cheap and efficient telephone service is now an absolute necessity in large business centres, and the larger the centre the greater the need. In Glasgow it may be said to be indispensable ; nevertheless our present service is neither cheap nor efficient. The annual rent is £10 and upwards per user, whereas in Canada on some exchanges the rates are as low as £1 per annum ; in Holland they range from £2. 10s. to £6 ; in Gothenburg from £3. 6s. to £6. 10s., according to the service given, and in Melbourne the charge is £6. In Stockholm, which has two very complete telephone systems, one being in the hands of the State authorities, the charge is only £4. 8s. 11d. per annum, which covers

free conversation within a radius of nearly 40 miles, and the service is a very superior one. It is interesting to note that Stockholm, with its population of 228,000, has upwards of 8,000 users, while Glasgow, with a population of 814,000, has not more than 3,500—there being one subscriber to every 27 inhabitants in Stockholm, while there is only one to every 230 in Glasgow. In order to give a cheap and efficient service two conditions must be fulfilled—first, a complete twin-wire system, combined with the most modern appliance, must be provided; and second, the strictest economy must be exercised in the expenditure of capital, so that rent may be chargeable only on the cost of the plant actually needed per user in addition to the usual working expenses. In small places, where there are few wires near one another, and where there is consequently little risk of contact and induction, a single wire is sufficient, the earth serving for the return current; but large cities cannot be efficiently served without a double wire or metallic circuit, because of the continual noises and interruptions going on. These are picked up if the earth is used for the return, whereas they are not heard at all over a twin wire. The electricians of the Post Office and the leading officials of the Telephone Company are at one on this point, as proved by their evidence before the Select Committee on the Telephone Bill on June 15, 1892; indeed, it is understood that the Post Office declines to connect any but twin wires with the new system of trunk wires it is erecting throughout the country. The amenity of the city is being destroyed by the network of overhead wires running in all directions, which need not exist, and which are a source of no inconsiderable danger. In order that the Corporation may take the matter in hand, all that is required is to apply to the Postmaster-General for a license, and, after obtaining it, to commence operations. Glasgow has already its electrical department, with conduits laid and to be be laid for lighting purposes, the conduits, according to the opinion of the engineers of the Post Office, being quite suitable for telephone underground wires. It can therefore give a perfect telephone service to the citizens much better and more cheaply than any company. Reliable estimates in detail have been prepared, showing that for a capital of about £15 per user the latest and best system can be laid down in Glasgow within the municipal radius. On this basis a thoroughly efficient service could be given at an annual charge of about £5 per user, or possibly less. £50,000 would be ample capital for a start, and if, as is likely, the 3,000 to 4,000 probable applicants for whom this would provide should be greatly exceeded, the necessary capital for additional users would be relatively less." After consideration of the memorandum, the committee unanimously agreed to recommend the Town Council to apply to the Postmaster-General for the necessary license to establish a telephone system in Glasgow. This recommendation will be considered by the Town Council at their next meeting.

High Temperatures.—An electrical process for obtaining temperatures very much higher than those at present realisable is spoken of by MM. E. Lagrange and Paul Hoho in the *Bulletin* de la Société Belge d'Electriciens. The authors talk airily, though not without restrictions, of temperatures of 800,000deg. C; and without going further than to say there is a suggestion of something realisable, it may be still desirable to give an idea of their statements. The voltaic arc gives a temperature of some 3,500deg. C. The authors studied, in a paper presented last year to the Académie, a luminous and calorific phenomenon which takes place in certain liquid conductors, at the contact between these liquids and one of the electrodes under certain conditions. This gives rise to very high temperature. The peculiar characteristic of the phenomenon is the formation of a gaseous sheath of high resistance around the electrodes. The energy of the current is transformed into heat, and as it is at the actual contact of sheath and electrode that the resistance is localised, the most intense heat is just at the surface of the electrode. The quantity of heat given off per square centimetre of the surface of the electrode is equal, per second, to the product $\frac{E\,I}{4{,}200\,S}$, where E is the potential between liquid and electrode, I the current, and S the surface immersed expressed in cm^2. In the paper to the Académie it was stated that the luminous sheath formed after the difference of potential had risen to a certain maximum variable with the nature and conductivity of the liquid. The current density increases with the conductivity, but not proportionally. With a solution of 55·5 per cent. by weight of sulphuric acid, at 75 volts the current density is 12·5 amperes per square centimetre, which gives as energy expended per second 957·5 watt-seconds, or 0·223 calorie. At increasingly higher voltages the current increases, but less quickly than the E.M.F.; it seems to increase very nearly as the square root only. If the difference of potential is 625 volts, the current will be three times its first value, or 37·5 amperes, and the quantity of heat given off 27 times greater, or $0{\cdot}223 \times 27 = 5{\cdot}921$ calories per second per square centimetre. Now this current of 37·5 amperes at 625 volts (the authors point out) already produces a temperature considerably higher than that of the arc of equal surface—that is, of the source of the highest present known temperatures. But, further, it can be demonstrated to what heights of temperature a body serving as electrode could be carried, under conditions easily realisable. Take as electrode a plate of graphite 1mm. thick and 1cm. square, and immerse it in a 10 per cent. solution of sulphuric acid at a difference of potential of 1,875 volts. In these conditions the current is 62·5 amperes per cm^2, and the total current issuing from the two faces and the lateral edges 114·75 amperes. The electric energy transformed in heat is, per second, $114{\cdot}75 \times 1{,}875 = 271{,}406$ watt-seconds, or 64·62 calories. The mass of the graphite plate is 0·00015 kilogramme, taking 1·5 as density of graphite. The specific heat being taken as 0·52 calorie, then the 64·62 calories per second is the heat required to raise the plate to the temperature of $\frac{64{\cdot}62}{0{\cdot}52 \times 0{\cdot}00015} = 828{,}460$deg. C.! This calculation has evidently no physical signification—it supposes the state of the graphite does not vary, and the specific heat remains constant; it leaves out of account radiation and conduction. Nevertheless, the 64 calories are given off at the surface, and in one second: and it is certain that at the end of a second the plate will have attained, especially at the superficial layer, a temperature inconceivably greater than any realised by present methods. Nor is this all, for voltages of 3,000 to 5,000 are at disposal if required. The authors conclude: "The following facts are to be observed: (1) When a current traverses an electrolyte, the latter is decomposed and the elements thus liberated are deposited on the electrodes in nascent state; (2) at the contact of one of these electrodes with the electrolyte there takes place the calorific action above set forth. At the contact with the electrode and the electrolyte, therefore, are united two actions—an electrical action and an excessively intense calorific action which are of a nature, under certain conditions, to enable chemical action to take place with very special energy. On this account we think it well to draw the attention of chemists to this physical phenomenon."

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

ARC LIGHTING.

(*Continued from page 9.*)

Diffusion of Light.—A number of people complain that the electric light, whether in the form of an arc lamp or incandescent lamp, is irritating and painful to the eye when looking at it. When the lamps are entirely uncovered, and the eyes are allowed to rest on the naked arc or filament, as the case may be, the above troublesome effect is not to be wondered at. It must be remembered that the light is of very great intensity, irrespective of the quantity of light, and that being so, concentrated rays require dispersing or diffusing. Daylight is light in the most perfect diffused state, and the source, the sun, need not be visible to our eyes at all. Moonlight, which is borrowed sunlight, is a beautifully softened light, although the shadows are strong. Contrast these with our methods of artificial lighting. We produce light by sprinkling about a greater or smaller number of points or concentrated sources of light, the light being intense close by, and diminishing rapidly at a distance. If we were to break up these points of light into a countless number of infinitely small sources, placed close together, we should then obtain a diffused effect. An ideal illumination of a room would be to have the whole of the ceiling to throw off a subdued and diffused light, thus converting the irritating and unpleasant points of light into large luminous surfaces.

A most simple example is to compare an incandescent lamp and a gas jet. It is much easier to look at the latter than the former. Why? Because the electric lamp gives its light from off a slender thread of carbon raised by intense heat to a white hot state. The luminous surface is here extremely small, but extremely intense. On the other hand, the light from a gas jet is given off from a broad surface, and the light is not intense. The quantity of light in each case is about the same: the former being a concentrated light, while the latter is less concentrated, and consequently more diffused.

We have not made one jot further progress in the art of illumination since the days of the ancients, when perfumed oils were burnt in their vessels; and so far as gas is concerned, we have taken a retrograde step, for whereas the oil vessels were costly articles and the burning of good oils produces a pleasant and soft light, the ugliness of gas brackets and the foulness of the gas burnt is universally known.

The intensity of the light of the electric arc is probably greater than any other artificial source of light. After gazing at a naked arc for a few seconds the eyes will be almost blinded, just as if one had looked at the sun. The temperature of the crater has been variably estimated, but 3,000deg. to 6,000deg. C. is near the right number. The light rays that are emitted from the glowing crater are only about 10 per cent. of the total rays, the other 90 per cent. being invisible, or dark heat rays, and yet this source of light gives many more light rays than other forms of artificial illumination; for example, a gas flame gives only from 3 to 4 per cent.

Arc lamps are now rarely run without having some kind of globe over them, except when used for lighting up large open spaces belonging more or less to private concerns—like dockyards, works, goods-yards, etc., where appearance is not considered provided they get the light. There are several different kind of globes used on arc lamps, each of which absorbs so much of the light: all of them help to diffuse the light and to lessen the shadows. By using very thick porcelain globes a great amount of light is absorbed or cut off, but against this disadvantage must be put the fact that the light available is well diffused and softened down, thus reducing the intensity and preventing deep shadows. The following figures give the probable amount of light that is cut off by different globes:

TABULATION 21.

Clear glass	10 to 20 per cent. loss
Thin ground glass	20 to 30 ,, ,,
Thick ground glass	30 to 40 ,, ,,
Thin opal glass	40 to 50 ,, ,,
Thick opal glass	50 to 60 ,, ,,

So that the light can be toned down to any degree by using a suitable globe.

The City of London Electric Light Company use a lantern having panes of ribbed prismatic glass, whereby the arc light is greatly magnified and softened down, so that the light rays are well diffused.

The value of a light for any particular purpose depends upon its composite rays, and the superiority of the arc light for illuminating purposes can easily be proved to be much beyond oil, gas, or any other artificial source. We will, therefore, analyse different kinds of light, and briefly sum up their composition of rays, taking the sun as the standard.

The light from the sun is composed of a number of homogeneous colours mixed together in a certain proportion, and forming what is called a "spectrum." The light given by the spectrum of the sun is colourless, and is called white light.

The colour of any substance or matter is regulated by the kind of rays which it *absorbs* from the light by which it is illuminated; for instance, a white substance, like snow or anything with a white surface, does not *absorb* any of the rays of the sun, but *reflects* them all back again, hence the snow appears colourless or white in daylight, because the light of the sun is white. A black surface, on the contrary, like coal, absorbs all the rays of sunlight, and so appears colourless or black. So when all the sun's rays are visible we have no colour, or a white appearance, and when none of the sun's rays are visible we have also no colour, or a black appearance. A substance having a yellow appearance signifies that all the sun's rays are absorbed except the yellow rays, and these are reflected back, thus giving the yellow tint. After this preliminary explanation respecting colours, we can now realise that a substance may present a different or modified colour when it is looked at in the light given from some artificial source.

The light given by gas, oil, or candles contains all the colours that the sun contains, but they are mixed in a different proportion; this is the same with the light of the electric arc. The tabulation below shows how the various coloured rays mentioned are distributed in the three illuminants—the sun, gaslight, and the electric arc.

The electric arc light is much nearer the light of the sun than any other artificial light; consequently, the natural colours of things are seen better by the electric light than by gaslight. Gaslight is particularly rich in the *red* or *heat* rays, while the electric arc is particularly rich in the *violet* or *chemical* or *actinic* rays.

The arc light is invaluable when colours require matching, because, with the exception of a very few shades, all the colours and shades known to us can be seen just as they would be in the light of the sun or daylight. A certain eminent silk firm made a thorough trial of the value of the electric arc in their mills, and they found that out of about 650 different colours and shades, there were only seven that could not be matched in the light of the electric arc. The writer cannot recollect what they were, but bronze was one of them.

TABULATION 22.—Colours of Rays.

Degree.	Yellow.	Red.	Violet.	Blue.	Green.
Rich	Gas.	Gas.	Arc.	Arc.	Gas.
Poor	Arc.	Arc.	Sun.	Sun.	Arc.
Very poor.	Sun.	Sun.	Gas.	Gas.	Sun.

Everybody knows how impossible it is to distinguish between shades of blue and green in gaslight. The above tabulation explains the reason why, there gas is shown to be very poor in blue rays, but very rich in green rays. A green substance reflects a small number of blue rays in addition to the green rays, and a blue substance reflects both blue and green rays. Therefore when a blue cloth is inspected by gaslight it will appear more or less greenish, because gaslight has plenty of green rays, but very few blue. On account of the great number of violet rays present in the arc light, the arc lamp is of great use in photographic work, such as the printing of negatives, etc.

(*To be continued.*)

ELECTRICAL MAINS AND METHODS OF LAYING.*

BY C. H. W. BIGGS, M.I.E.E.

Let me at once say that this paper pretends to nothing more than a kind of preliminary, dealing generally and elementarily with many subjects that, to be thoroughly discussed, would each need a paper of an elaborate character to itself. The view taken is that municipal engineers have not, as a rule, made a special study of electrical matters, yet, in the ordinary course of things, they may be called upon more or less suddenly to deal with these questions. Generally, so far as my experience goes, those who try to throw a little light on the subject talk too much about dynamos and the paraphernalia of the generating stations, and too little about the expensive part of the plant required for distribution.

The members of this institution are responsible for the condition of the roads, streets, and pavements of the kingdom—hence, whatever interferes with these must be considered of interest; but in addition to the mere maintenance of streets, one of the most onerous duties of the borough engineer is the giving advice to his council in matters electrical. As one who is doubly interested in these matters—on the one hand from the municipal, and on the other from the electrical standpoint—I am naturally anxious to elicit information as to the exact conditions each party requires fulfilled. If the municipality—as I hold it ought to do—undertakes the production and distribution of the means to provide for the artificial illumination of the district over which it holds sway, it will have full and complete control of the generating stations and the system of distribution.

With the generation of electrical energy I have little to do in this paper, except to assume that it will be generated either on the high or the low pressure system. If generated on the high-pressure system, it may be either to give continuous or alternating currents. If the alternating system is adopted, most probably a different kind of main will be used than if on the continuous current. The reason of this may be explained. According to the researches of Lord Kelvin, Oliver Heaviside, and others, the phenomenon which we call current in alternate-current work affects only the external part of the conductor. The slower the alternations, the greater the sectional depth of the conductor that takes part in carrying the current; the more rapid the alternations, the less the depth of conductor so acting. Hence the view has arisen of late years that the conductor is more of a directrix than anything, and given sufficiently rapid alternations, the action is a mere surface action between the dielectric and the conductor. Thus the conductors for alternate currents are sometimes hollow metallic tubes—in fact, copper tubes—in order to obtain a large surface area. Mr. Ferranti was, I think, the first to arrange the outgoing and the incoming tubes concentrically in his mains from the Deptford generating station to the Charing Cross and other districts supplied from Deptford.

It will be best to avoid as far as possible the discussion of purely electrical matters, except so far as they bear directly upon the object of this paper. Assume, then, that we wish to generate a given quantity of electrical energy and utilise it at a certain point. What difference will it make to our mains if it is generated under high pressure or under low pressure? The heat developed in a conductor is given by the well-known formula C^2R—"current squared" × "resistance"; from which it is seen that a small increase of current may mean a considerable increase of heat. We neither want our mains melted, nor, in fact, made hot, we want the heat evolved at the lamps, for elsewhere it means loss. The heating of the conductor increases the loss in another way, as it also increases the copper resistance. By generating under high pressure we obtain our quantum of electrical energy with little current, the energy being represented by the product of "current" × "pressure." In the formula $C\,E$, C = current; E = pressure. Increasing the pressure means decreasing the current, and a small current means a small conductor, which, as copper is generally used, means a saving of copper. On the other hand, the current will traverse any road it can find, and it goes over these roads in quantities inversely to the resistance to its progress these roads offer. In our operations we want it to go over a particular road, and not meander away in other direction, being thereby lost for our work, not to mention the danger arising to both life and property from its being where it is not wanted. With high pressure, then, we have to be exceedingly careful as to the insulation of the conductor. Hence, while we gain by saving copper, we lose something by having to use more costly insulation. Mains must be constructed so as to avoid loss from heating and loss from leakage. There is still another point to which attention must be directed. If we use our electrical energy for lighting purposes, we want the current to be as large as possible at the point of use, because its value for the object in view varies as its square. The electrical energy may be generated at a high pressure and a small current, but it is used at a lower pressure with larger current. If our apparatus were perfect we might convert 2,000 units of pressure (called volts) × 2 units of current (called amperes) into the equivalent energy: 100 volts pressure × 40 amperes current. The piece of apparatus for such conversion is called a transformer. Some of the advocates for high pressure would supply a transformer to every house, others prefer a transformer to a group of houses. Whichever plan be adopted, the cost of transformers has to be considered. This extra piece of apparatus must also add to the cost of maintenance. Further, unless the transformer be absolutely cut out of the circuit when it is not required in the production of light, it is constantly using up more or less current in order to keep the iron core magnetised, which is another source of loss.

Summarising, high pressure requires less copper in the mains, but more and better insulation. It requires the use of transformers, either in every house or at sub-stations for a group of houses. These transformers have to be paid for initially and have to be maintained; they also lead to a smaller or greater constant loss of current. The great advantage of high pressure is in enabling the central station to be erected in places where land costs less than where the position is more rigidly defined, where fuel and water are more cheaply obtained, and other similar advantages. Low-pressure working requires the central station to be at hand (according to the calculations of Messrs. Crompton and Wright, the distance must not exceed from 2,000 to 2,500 yards), and it needs more copper in the conductors. As generally adopted, low pressure (the limit of which is 500 volts) also requires transforming, but in a different way to that adopted with high pressure. This naturally leads to a few words about the

Three Wire System.—If we have a dynamo generating at 100 volts pressure, the pressure ordinarily required by the lamps, the current can be used at that pressure without transformation. There must be a complete conductive circuit (main) from one terminal of the dynamo to the other, and usually the lamps are placed across the mains. Fig. 1 shows this. A and B

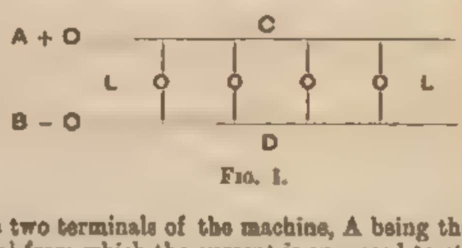


FIG. 1.

are the two terminals of the machine, A being the positive terminal from which the current is supposed to start. Let C be the main or lead from A. Let D be the main or lead going back to the negative terminal, B. The lamps, L L, are joined to these mains by wires as shown, and the current from A divides itself equally (if the lamp resistances are all the same) through these wires and lamps. Here we want two mains. Another similar dynamo would also require two mains, or the two dynamos, working separately, each giving 100 volts, would require *four* mains. We can, however, couple up these two dynamos, so as to get from the coupled machines a pressure of 200 volts. This is done by connect-

* Paper read before the Incorporated Association of Municipal and County Engineers at the Annual General Meeting at West Bromwich, July 13, 14, 15, 1893.

ing the negative terminal of the one machine to the positive of the other, as B to A_1, Fig. 2. The machines apart, we want the mains C, D, E, F; when coupled it is found that one of the mains, D or E, can be dispensed with, saving its cost, and the system then has but three mains, as in Fig. 3. This central main has to carry only a difference of current, hence, usually may have a less sectional area of copper. In practice the area of copper in this third wire is made half that of the mains.

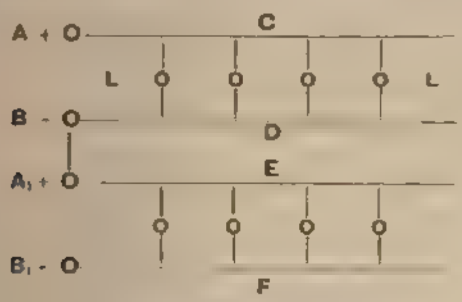


Fig. 2

The total pressure between A and B_1 is 200 volts, but between any two of the mains it is only 100 volts, the pressure required for the due working of the lamps. This, then, is the three-wire system, about which we hear so much, and which, in fact, is a transforming system, without special apparatus, and without much of the loss that pertains to such apparatus. You can easily see for yourselves how the three-wire system can be extended. You will also easily see that there comes to be a point when transformers are to be preferred to mains. A careful examination of the subject will inevitably bring you to the conclusion that the real test all round is cost of maintenance rather than initial cost. It would take too long to discuss this fully, but one phase of it may be examined, and for this particular examination I am indebted to a friend. His contention, with which I fully agree, is that cost price and cost of maintenance of mains affect differently supply companies and municipalities.

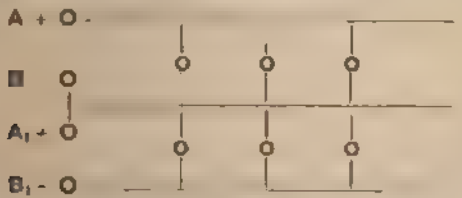


Fig. 3.

Assume the question to be whether to use the very best vulcanised rubber cables (as made by the Silvertown Company or any equally good maker) or a less costly insulated cable. The test of time so far has shown that where the best vulcanised rubber cables have been carefully made and laid the cost of maintenance has been very slight, while the prime cost is high. The whole question resolves itself into the cost of money. A supply company pays, say, 5 per cent. on debentures; a municipality gets all it wants at 3 per cent. Now take the two cases:

1. A prime cost of £12,000, and an annual cost for maintenance of £80

2. A prime cost of £10,000, and an annual cost for maintenance of £200.

For a Supply Company.—First system:

£12,000 at 5 per cent.	£600	
Sinking fund, say, at 2 per cent.	240	
Cost of maintenance	80	
Total	——	£920

Second system:

£10,000 at 5 per cent.	£500	
Sinking fund at 2 per cent.	200	
Cost of maintenance	200	
Total	——	£900

For a Municipality.—First system:

£12,000 at 3 per cent.	£360	
Sinking fund at 2 per cent.	240	
Cost of maintenance	80	
Total	——	£680

Second system:

£10,000 at 3 per cent.	£300	
Sinking fund at 2 per cent.	200	
Cost of maintenance	200	
Total	——	£700

These figures are taken at random merely to put the matter in a concrete form, to show that the greater prime cost is warranted by the results so far as the municipality is concerned. They get better materials and better work, and should obtain better results because they can get their money cheaply. There is also the greater convenience to the public when the maintenance is low, because of less interference with streets and roads. It is therefore important to you to know not only the purity and conductivity of the copper, and the insulation resistance, but to know whether the insulation proposed deteriorates with time, and how rapidly. Unfortunately, too little attention has as yet been paid to this item, but slight enquiry will prove that in many cases large amounts have been expended which, rigidly examined, come under cost of maintenance, but have been placed to capital account.

It is impossible to give the exact details of manufacture of all the specimens of mains before you. They are all from well-known makers, whose reputations stand high in the manufacturing world. Some of these specimens are what we call "armoured"—that is, covered with a protecting wire. This is a mechanical protection which will be again referred to when considering methods of laying the mains. Other mains are lead-cased, this lead covering being almost indestructible, and therefore preserving the insulation. Wires insulated with vulcanised indiarubber, and the lead-cased cables are now almost exclusively used in first-class installations if we except the use of bare wire when the insulation is air.

We may without fear take the practice of the Silvertown Company (its lengthy name is the India Rubber, Gutta Percha, and Telegraph Works Company, Limited, but life is too short to say this) as what should be always looked for by buyers. Following the practice in the manufacture of submarine cables, they subject their manufactures to what may be practically termed continuous tests. All vulcanised wires, cables, etc., are, during manufacture, subjected to temperatures over 200deg. F. They are all tested in water, with at least 500 volts pressure, after being immersed over 24 hours. The test for insulation is taken after one minute's electrification. A certificate of the test is issued with every length of not less than 110 yards of the standard vulcanised classes. Of course the high-pressure mains are subjected to tests with much greater pressure—generally double the working pressure. The specimens before you have been kindly placed at my disposal by the Silvertown Company, Messrs. W. T. Henley's Telegraph Works Company, the Telegraph Manufacturing Company (Helsby), Messrs. W. T. Glover and Co. (Salford), and the Fowler-Waring Company. With regard to lead-covered cables, the system of covering adopted by Messrs. Siemens is almost perfect. The lead tube is produced from a carefully-prepared solid cylinder of cold lead, which is forced under great pressure in a hydraulic press to flow out in one continuous stream round the cable, thus forming a lead tube without seam, and one which therefore has no tendency to open at the seams or allow the penetration of moisture. After leaving the press, every length of cable covered is put under water, and goes through careful testing to ascertain beyond doubt that it is in perfect condition.

After these preliminary remarks about the cables themselves, I will consider the methods of laying (1) with bare wires, (2) insulated wires and a drawing-in system, (3) protected or armoured insulated wires.

First—The Bare-Wire System.—In order that you may have the very latest information as to the practice, Mr. Crompton has favoured me with the details of what he is doing at Hove. Perhaps the better plan is to give the specification of the work, which is as follows:

Electrical Conductors at Hove.

System.—Wherever there is sufficient depth under the footways the conductors will take the form of the Crompton

system of bare copper strip, strained against and supported upon porcelain insulators in concrete culverts, as shown, Figs. 4, 5, and 6. Where there is insufficient room under the footways for these culverts, insulated cables will be laid drawn into Davis-Crompton cast-iron casings, as shown, Fig. 7. If, owing to the position of the cellars and other obstacles, there is insufficient room for the Davis-Crompton casings, wrought-iron pipes will be singly laid, corresponding in number to the cable ways in the casings. Wherever distributing mains are laid service-boxes will be placed at intervals, so that any house along the route may be readily connected to the system. When the mains cross roads or carriageways they will take the form of insulated cables, drawn into Davis Crompton casings, or, in exceptional cases, wrought-iron pipes.

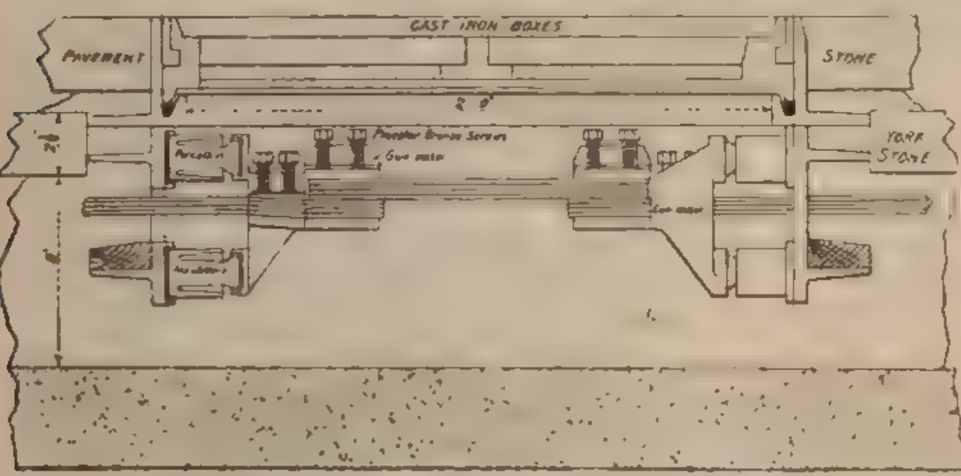


FIG. 4.—Longitudinal Section of Straining-up Box, showing Joints.

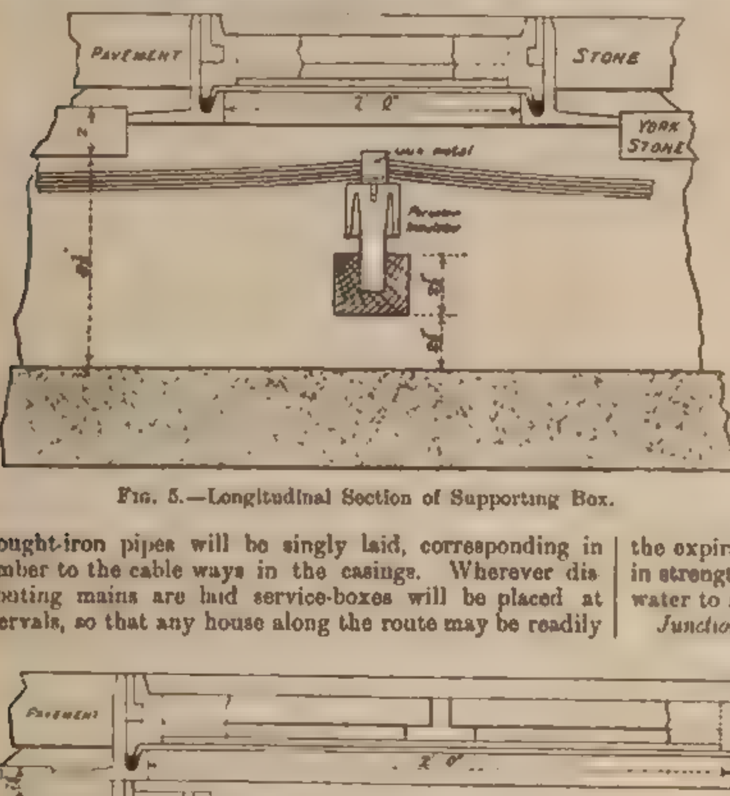


FIG. 5.—Longitudinal Section of Supporting Box.

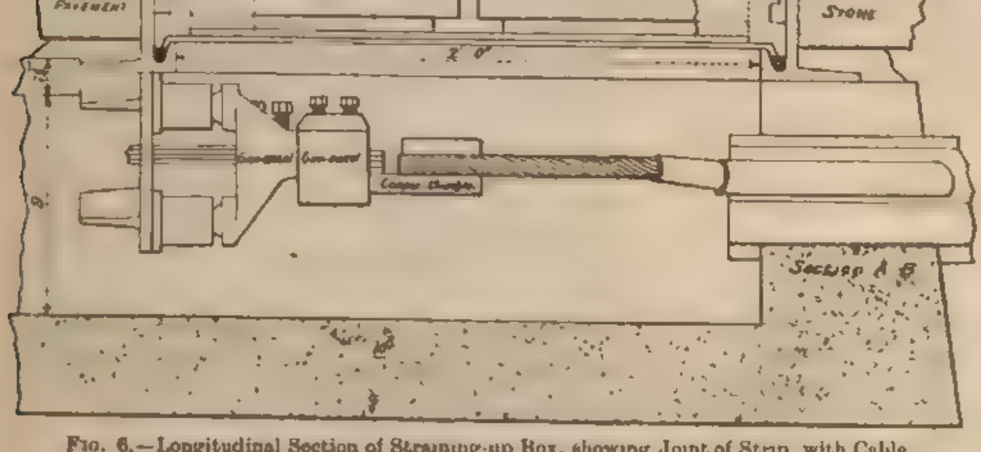


FIG. 6.—Longitudinal Section of Straining-up Box, showing Joint of Strip, with Cable.

Concrete Culverts.—The culverts will be constructed as shown, Figs. 8, 9, and 10, in three sizes—viz., 9in., 15in., and 20in. for three, five, and seven conductors respectively. The sectional area of each of these conductors can be varied from ·125 of a sq. in. to one sq. in. The walls of the culverts will in no case be less than 6in. thick, and the bottoms will be not less than 4in. thick. The culverts will be covered with self-faced York stone, which will be bedded in cement, and all the joints made as watertight as possible. The concrete of which the culverts are to be constructed will be composed of one part of cement to six parts of good pit ballast or shingle. The culverts will be rendered inside with cement and sand in the proportion of four sacks of cement to one yard of sharp pit sand.

Cement.—To be fine Portland cement weighing not less than 112lb. and not more than 116lb. per striked bushel. Briquettes which have been placed in water 16 or 17 hours after gauging, at the end of seven days, to have a tensile strength of not less than 350lb. per square inch, and at the expiration of 28 days from gauging to have increased in strength at least 25 per cent. Pats left in air or placed in water to show no cracks or other signs of deviation of form.

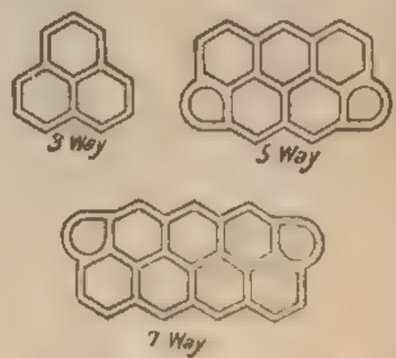


FIG. 7.—Crompton-Davis 3, 5, and 7 way Casing.

Junction and Service Boxes.—The junction and house service boxes will be constructed of bricks wherever Davis-Crompton casings or pipes take the place of concrete culverts.

Drains. — The culverts will be efficiently drained by means of 4in. barrel drains connecting them to the gullies or sewers.

Insulating Gear. — The straining girders will be of cast iron dipped in Angus Smith's composition. The bars on which the supporting insulators rest will be of the best English oak boiled in Stockholm tar. The straining and supporting insulators will be of glazed porcelain carefully annealed. The bridge-pieces will be of gunmetal fitted with manganese bronze or Delta metal screws. The caps for the supporting insulators will be of gunmetal.

Davis Crompton Casings.—These casings will be of good

quality cast iron, in lengths of 6ft. and 3ft. respectively, and will be coated with Angus Smith's composition. These casings to be constructed with three, five, and seven cells, to correspond with the three sizes of culverts. The five-way and seven-way casings will be provided with two extra cells of smaller dimensions for the reception of test wires, telephone or other signalling wires.

Conductors.—The bare copper conductor to consist of strip in every case 1in. wide, the thickness being varied, according to the section required, between $\frac{1}{8}$in. and $\frac{1}{4}$in.—

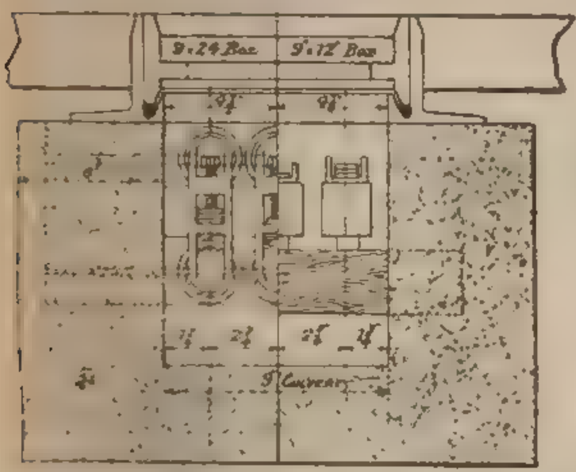


FIG. 8.—Section of 9in. Culvert.

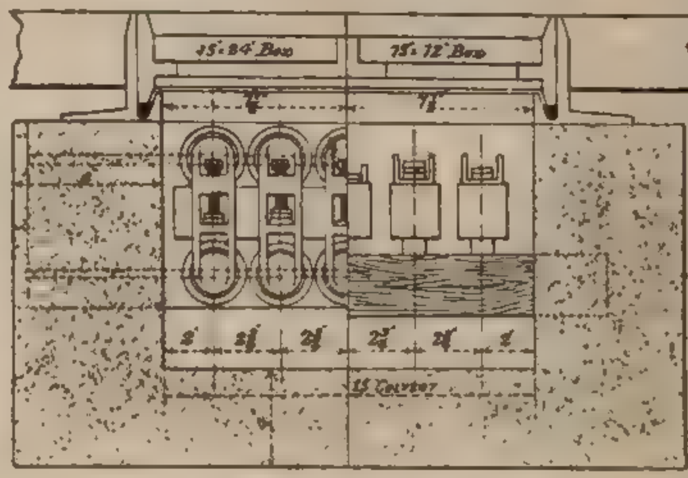


FIG. 9.—Section of 15in. Culvert.

the total cross-section required being built up of a number of such strips superposed. The insulated conductors will have a conductivity of not less than 98 per cent., and the insulating material will be Henley's vulcanised and ozokerited indiarubber, the insulation resistance being approximately 2,000 megohms per mile—the test being applied in the usual manner, in immersion in water before the cables leave the maker's works. The conductors used for test wires being in most cases composed of three $^7/_{22}$ Henley's A A quality conductors made into one triple lead.

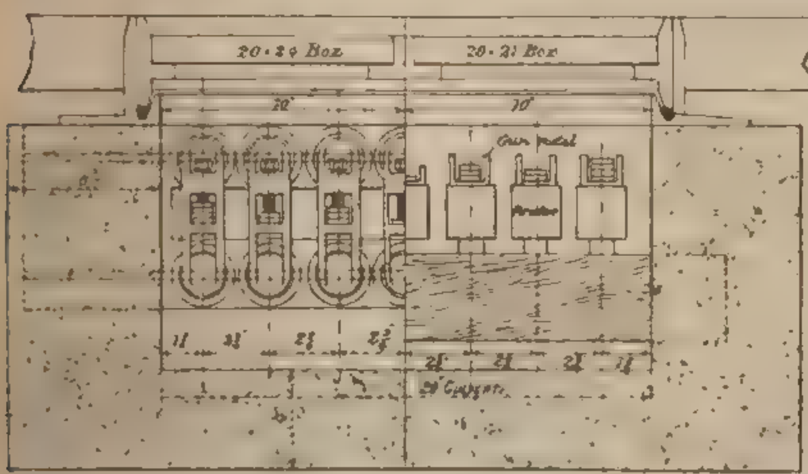


FIG. 10.—Section of 20in. Culvert.

Pavement Boxes.—The pavement boxes will be of the following inside dimensions:

	Junction-box.	House service-box.
For 9in. culvert ...	24in. by 9in. ...	12in. by 9in.
For 15in. culvert ...	24in. by 15in. ...	12in. by 15in.
For 20in. culvert ...	24in. by 20in. ...	12in. by 20in.

They will consist of a cast iron frame, into which a cast-iron cover closely fits, the joints being made watertight by means of a tongue and groove joint with suitable packing. The cast-iron covers may be filled in with cement or asphalte to suit surrounding footways.

It is, of course, impossible to give exact prices, but the following will assist in forming an idea of cost. The prices are for not less than one mile of Crompton underground mains laid at one time, and on the basis of copper at 7d. per pound. The making good of pavements, etc., is not included, as this varies considerably.

3-way culvert; boxes every 15 yards	14s. 5d. per yard.
5 " " "	16s. 10d. "
7 " " "	19s. 10d. "
3-way Davis-Crompton casing "	10s. 3d. "
5 " " "	13s. 3d. "
7 " " "	15s. 0d. "
Insulating gear for the system, per yard run..................................	6d.

Copper strips, jointed and strained up in position	11d. per lb.
5 sectional area cable per yard run laid, A quality	14s. 9d. per yard.
25 ditto	7s. 3d. "
125 ditto....	4s. 0d. "
Triple potential lead per yard run laid	2s. 1d.

Insulated Wires and Drawing-in.—The system just mentioned uses bare copper, and depends upon the air for its insulation. It is not everybody that believes in air insulation even for low pressures, and we all know that it is merely a question of more pressure to break down any air insulation. But while dry air is a good insulator, damp air is not. It is unnecessary to enter into a description of how moisture may condense upon wires and insulators, and thus practically get rid of the insulation of the bare wire. The troubles hitherto arising from the use of the bare-wire system are said to be less in extent than when using insulated wires. I simply deal with the fact that both systems are used, and while it would for numerous reasons be an admirable plan to make a subway or conduit for insulated wires it would add to the cost of laying. There are, broadly speaking, two methods followed—one, the laying of iron pipes in trenches, and subsequently drawing the mains through these pipes, or instead of iron pipes, using bitumen pipes or casings. Whether iron or bitumen be adopted, each main should have a separate tube for its own use. If you have two or more mains in one pipe you cannot draw them in and out without injury to the insulating material, and it is imperative that this should be injured as little as possible. Drawing-in boxes are built at intervals as required. Usually the course of the main is first laid out and the trench dug to the required depth. The trench is made in as straight a line as possible, and is carefully levelled, a good foundation being obtained by ramming, or sometimes by a layer of concrete. As long lengths of trench are operated at a time as the authorities will allow. If bitumen casing, Fig. 11, is used these are in 6ft. lengths, and have to be jointed *in situ* so as to obtain one continuous casing. If I may digress here for a

moment it is to say that one of the most important operations connected with mains is the jointing, and the jointing of the casing is not less important. The great objection is to moisture, and if the casing is not properly jointed moisture will get to the insulated wire. Mice and rats are also pests to be avoided. They are no respecters of insulation, and no

Fig. 11.

doubt many a one has met his death from nibbling where not wanted. To resume, two lengths of bitumen are laid close to each other with, say, 2in. space between. Mandrels are pushed through each hole in the casing joining the two sets of holes together. Hot bitumen concrete is then run round and shaped to the shape of the original casing. The mandrel is furnished with a hook to which a cord is attached, so that when withdrawn the cord is run through the casing; this, of course, being required for the drawing in of the main. Where mandrels cannot be used, the ends are butted together and a saddle, Fig. 12, of the material

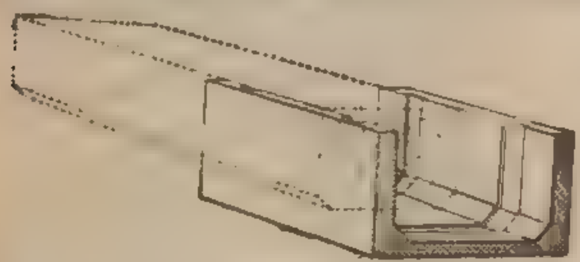


Fig. 12.

placed round, the joint being made sound by a little bitumen seared with a hot iron. When iron tubes are used, similar care is taken to get waterproof joints. The drawing in boxes are of various sizes, generally constructed of brickwork, and well drained. The casings, whether iron or bitumen, project a few inches into the pit, one form of which is shown in Fig. 13. The cover plates are of iron, filled in with cement to match the pavement. The cost of this system varies considerably, principally through the

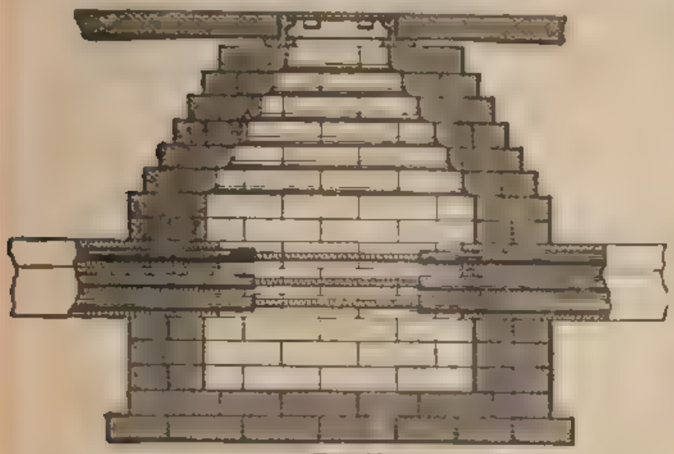


Fig. 13.

different prices charged for excavating and making good. Thus we may take it that—

Cost of excavating and making good varies from 3s. 6d. to 20s. To whatever this comes to must be added:

Cost of casing, iron or bitumen.

Cost of laying casing—say, 2½d. to 3d. per yard for iron.

Cost of cable (10 per cent. off list prices delivered in England).

Drawing in cable, jointing, superintendence—say, 2d. to 4d. per yard.

Drawing-in boxes—say, 1s. per yard.

Of the advantages claimed for the drawing-in system, that which will commend itself to your notice is the ability to examine, repair, or replace the wires without interference with the street traffic, and without much interference with the pavement traffic.

Using Protected Wires.—Some engineers contend that once a main is laid it should not require repair or replacement, if of proper dimensions, properly insulated, and properly laid. They therefore adopt a main covered with iron wire or tape sufficiently strong to resist the blow of a pick or a shovel and lay it in a trench. Others modify this a little, and make a wood trough, into which the wire is placed upon a bed of bitumen or other insulating material. The trough is then filled up with similar material, the top put on, and the trench filled in. Service-boxes are placed at intervals, so that connections can easily be made.

In either of the systems mentioned, it is often arranged that the district lighted is divided into smaller areas, each of which is supplied by its own distributing system, each such distributing system being supplied by special feeding

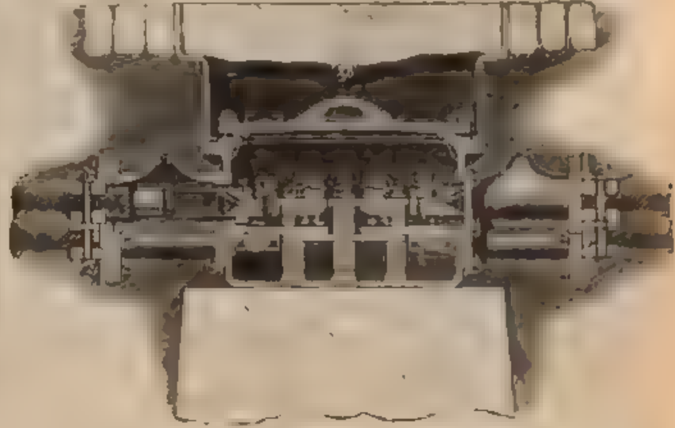


Fig. 14.

wires. In these cases the ends of the feeding mains are led to distributing boxes, from which it may be a number of pairs of distributing wires are led. Messrs Siemens's arrangement for these feeding-boxes is shown in Figs. 14 and 15.

The feeding-boxes consist of a square cast-iron box with a cast-iron cover, over which is a separate manhole frame reaching up to the level of the road or footway, and closed by stone slab with a ring bolt for lifting, or by an iron frame with wood paving as circumstances and locality require. In the cast-iron box there are two sets of contact bars placed vertically above one another, resting on, and

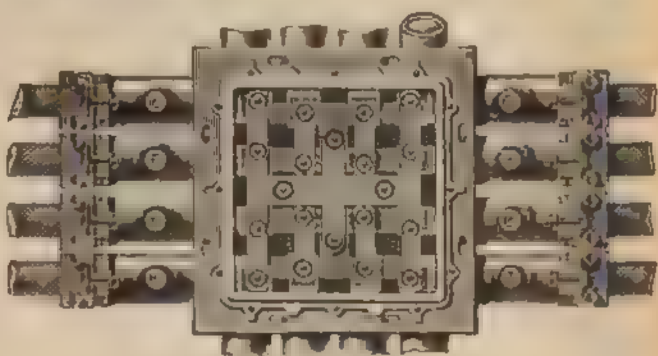


Fig. 15.

insulated by, ebonite pillars, one set being for the positive and the other for the negative mains. Opposite each of the terminals belonging to the two contact bars are circular holes cast in the walls of the box, which serve for the introduction of the cables. Holes in the sides of the boxes which are not immediately required for cables must be closed with blind flanges and india-rubber washers to prevent moisture entering the box. The cables are fitted with end connections, and are brought into the feeding-boxes through coupling boxes, Fig. 16, which being bolted to the feeding-box and to the cable hold the

latter rigidly in position. The coupling-boxes are filled with hot compound, and moisture is thus prevented from entering the cable ends or the feeding-boxes. Feeding-boxes for cables laid on the three-wire system have three sets of contact bars instead of two, but are otherwise of the same construction as those described above, and the connections are made in exactly the same manner.

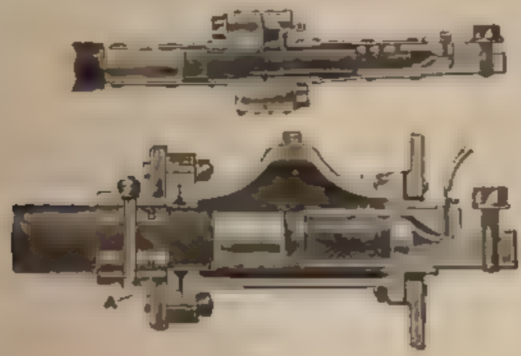


FIG. 16.

Among the mains which are laid according to the last plans are those of Mr. Ferranti, who, as I have said, takes concentric tubes of copper and insulates them from each other. These tubes are in 20ft. lengths, and are insulated the one from the other by means of waxed paper. The paper is thoroughly dried and then saturated with wax, and placed around the inner tube by means of rollers, great pressure being put upon it to make a solid insulation. The insulated concentric tube is then slipped into a second

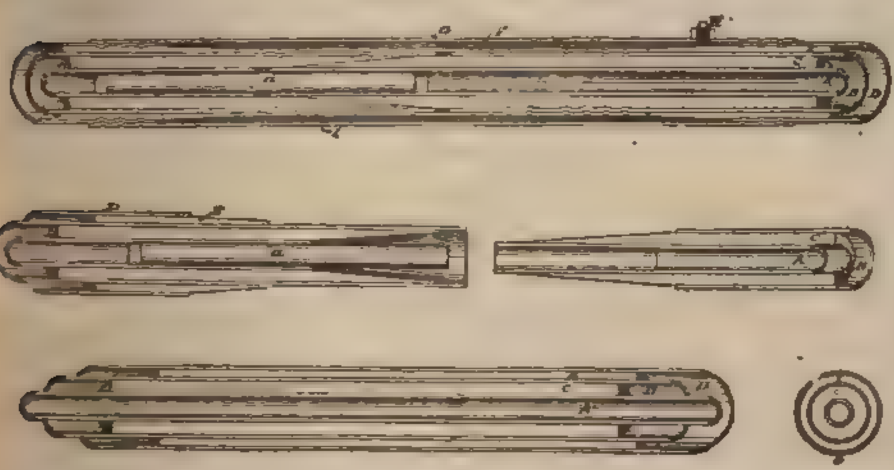


FIG. 17.

tube, which is similarly insulated, and the whole slipped into an outer iron tube to act as a protecting shield. Melted wax is forced in between the tubes, completely filling the space and making the insulation perfect.

But the principal reason for my calling attention to this concentric conductor is from the interesting manner in which the joints are made. The accompanying figures (Fig 17) show sections of the main and method of jointing. One end of each length is formed into a long projecting cone, the other end into a hollow cone by means of a special

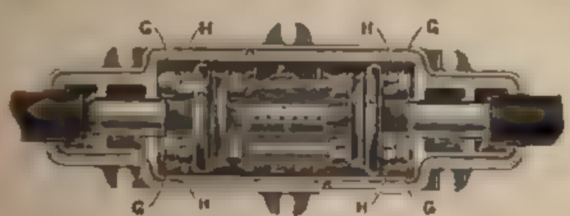


FIG. 18.

lathe. This operation is to exactly the same taper, and the lengths are capped and sent out to the spot in the following manner: A tight-fitting copper rod, 12in. long, is driven into the inner tube of the hollow coned end. A tight-fitting sleeve of copper is driven for a distance of 8in. on the outer conductor of the main to which it is to be jointed, and firmly gripped by a special tool. The two cones are then inserted one within the other, the surfaces having been previously warmed, and are forced together and driven home by screw clamps, a total pressure of about three tons being employed. While under this pressure the copper sleeve is firmly locked to the outer conductor by means of circular corrugations. The sleeve and the outer insulation are wrapped at the junction with insulating material until they become of the same external diameter as the iron tube, when an iron sleeve, 30in. long, is passed over the joint and corrugated down at both ends. In order to fill up any air space in the outer insulation, hot wax is forced through the boss of the iron sleeve. It is then closed with a gas plug. Many thousands of joints have been made in this manner, and when carefully done have been satisfactory.

Some manufacturers have approached the jointing of concentric cables—not the copper tubes, but concentric wire cables similar to those before you — in a different manner. The system adopted by Messrs. Siemens for straight joints, Fig. 18, is a longitudinal cast-iron box, A, in halves, for the protection of the joint. A tinned brass tube, B, to connect the two central conductors, and four tinned metal flanges, C C, D D, with two tinned copper bolts, E E, to connect the two outer conductors. Two of these tinned metal flanges, D D, have ebonite rims round their circumference to prevent the internal fittings from making contact with the outer cast-iron box. The inner conductor is jointed, and the cast-iron box is made watertight. Fig. 19 shows a T-joint for concentric cables, consisting of a T-shaped cast iron box, A, in halves, for the protection of the joint, a tinned brass socket, B, for joining the central conductors, also T-shaped, and six tinned metal flanges, C D, with one tinned copper bolt, E, four tinned steel bolts, F, three tinned steel screws, G, and two strips of tinned sheet copper to connect the outer conductors. Three of these tinned metal flanges, D D, have ebonite rims on their circumference to prevent the internal fittings from making contact with the outer cast-iron box.

There are similar arrangements for jointing lead-covered cables, but the difficulty of deciding what to say within the limits of a short paper must be an excuse for now expressing a hope that at some future time I may perhaps be permitted to deal in an elementary manner

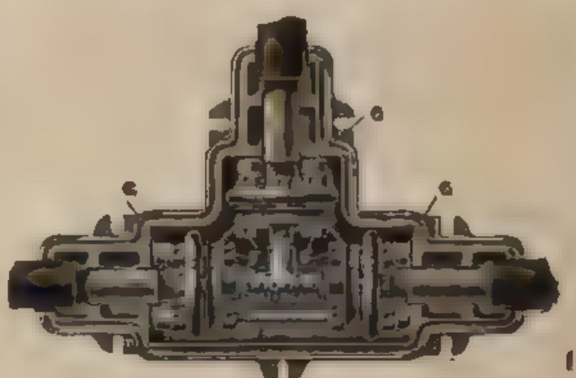


FIG. 19.

with the electrical branch of the subject, and a consideration of the two will enable us better to decide which combination is most likely in practice to be economical and effective.

THE

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CONTENTS.

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THE NATIONAL TELEPHONE COMPANY.

This company now justifies its name, for it has succeeded in practically obtaining control of by far the larger part of the telephonic interest of the country, and, according to the report just issued, has made arrangements for acquiring the Telephone Company of Ireland. The accounts to be presented to the meeting next Tuesday are worthy of careful consideration. Unfortunately, with all the will in the world, the exact position of a company is rarely obtainable from its published accounts. The authorised capital of this company is four millions, and it has expended some £23,000 over this huge amount. Some £300,000 of the capital is in 6 per cent. preference shares, and of debenture stock £726,477 has been issued. During the past financial year £344,776 has been expended on purchasing other companies, and £305,799 in constructional work. The largeness of the transactions during the past year are seen from the fact that there is £70,000 advanced by the bankers, and £120,000 by the New Telephone Company, on which interest is paid. The reserve fund seems to have been used to the full, but of course the most important question is the relation of the balance between revenue and expenditure to capital. The revenue account shows over half a million of receipts, against an expenditure £221,218. 11s. 10d. less, that being the amount of profit to be dealt with. Of this sum, after paying parliamentary expenses, interest on loans and debentures, there remains a balance for the shareholders of £181,562, which, after putting £30,000 to reserve, admits of a 5 per cent. dividend on the ordinary and third preference shares, and 6 per cent. on the first and second preference shares, leaving £2,194. 14s. 3d. to be carried forward. The directors in their report say: "The distribution on the ordinary shares of 1 per cent. less than in the preceding year is recommended by the Board chiefly in view of the desirability for strengthening the position of the company by carrying an adequate annual sum to the reserve fund." Some readers may look through the published accounts for evidence of allowance for depreciation, but an item under that heading will not be found. We take it that the directors would say their policy is to maintain their lines in the highest state of efficiency—that such maintenance is charged to revenue and paid for out of revenue, and there is an item of over a hundred thousand pounds for maintenance and renewals. That policy is to be commended, but we do not think that the value of the property is the value of the capital expended on it. The business may be very lucrative, and therefore lend itself to the much watering of capital; but the fact that such a lucrative business is unable to carry its shares to par shows a source of weakness somewhere. This report and balance-sheet comes at an opportune moment. Perhaps before these words see the light another report may be issued—that of the joint committee to determine questions of telephony *v.* traction. Will this report be favourable or unfavourable? If the latter, what effect will it have upon the telephone interests? It is not our province to predetermine this report,

but one thing is evident, that if it be unfavourable, the National Telephone Company will be compelled to alter its whole system to a twin-wire system. This work may not have to be carried out at once, but come it must; and the directors are evidently preparing for the inevitable by increasing their reserve by the large sum of £30,000. They have spent enough money in trying to avoid the twin system that would have gone far towards paying for it, and it is time wiser counsel prevailed. As we say, counsel may not be needed, and the work may be compulsory, but even if the report be favourable to the telephone interests—a matter considerably in doubt—we think it would be far wiser for the directors to hasten on the change rather than to delay it.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ACCUMULATOR TRACTION.

SIR,—With reference to Mr. Sellon's remarks in your issue of the 7th inst. on accumulator traction and on our statement re the maintenance rate of 1½d. per car mile for our cells, whether this latter be bald or otherwise, at any rate it is founded on fact. Of course, this, by itself, does not sum up the advantages of the accumulator system, but it eliminates in a satisfactory manner the only doubtful factor which hitherto existed in estimates of the running expenses, and if taken in conjunction with the other results of working—(1) repairs, none; (2) renewals, none since December, 1892; (3) supervision and attendance, next to none; (4) coal bill, reduced; (5) record of stoppages from all causes, almost a blank, all corroborated by the managing director of the Birmingham Central Tramway Company (Mr. Carruthers Wain) at the meeting of the Tramways Institute of Great Britain and Ireland on June 29—then we maintain that our case is proved beyond doubt. Whatever the outcome of the balance-sheet may be, it can only show whether the management has understood to take advantage of thoroughly efficient cells handed over to them to make their line pay or not. The cost in connection with the working of our cells being accurately and reliably determinable to within a small fraction of a penny, the financial results of any line on which they are used will depend entirely upon the management. Economic boilers, efficient engines and dynamos, motors, and gearing, sound rolling stock and permanent way, cheap way-leaves, and a careful watch over the wages expenditure are essentials to success. Where all these points receive due attention the line will pay, provided the traffic warrants its existence.

We did not say in our letter that the working of the Bristol-road section of the Birmingham Central Tramways is cheaper than any direct-current system. The working is not in our hands: we have no voice in the management, and not the remotest check on the expenditure. We do not believe in and never make random statements: they cannot lead to satisfactory results. An offer has been made by us to the Birmingham Central Tramways Company, Limited, to work the line ourselves, guaranteeing a maximum cost per car mile, and this offer we understand is under the consideration of their Board. Regarding the other sections of the Birmingham Central Tramways Company's system, we did not mention them in our letter, and consequently could not have indulged in any comparisons therewith. How the "balance-sheet" can possibly enlighten Mr. Sellon as to the "regular and reliable working" we confess we do not know: we always expected the "daily returns" to supply this information in the most trustworthy and straightforward manner.

In conclusion, we beg to say that we shall be very pleased to have an opportunity of submitting to Mr. Sellon such evidence as will we are confident leave no doubt whatever upon his mind, if he be open to conviction, that we are fairly and honestly entitled to any and every claim advanced by us for our cells and for accumulator traction in this correspondence and on any other occasion.—Yours, etc.,

L. BROEKMAN, Manager,
The Epstein Electric Accumulator Company, Limited.
London, W., July 11, 1893.

ECHOES FROM THE WORLD'S FAIR.

BY ARTHUR F. GUY.

The following jottings are taken by the writer from a conversation held with a friend, Mr. A. L. C. Fell, who has just returned from the scene of the Yankee's "Biggest Show on Earth," otherwise known as the World's Fair at Chicago.

The buildings at the fair are described as most handsome and imposing, and their appearance would lead the casual observer to imagine that they were built from pure white marble, whereas the effect is really produced by wood and plaster of Paris. Nearly all the various structures are adorned with numerous fine moulded statues, which give a finishing touch to their beauty. The illumination of the grounds by night presents a scene of wonderful brilliancy, and provides a perfect feast for the eyes. Probably the most enjoyable way of obtaining a view of the buildings and grounds, is to pay "half a dollar for the round trip," and take a seat in one of the electric launches which ply on the lagoons, then, sat at ease, an ever-changing scene unfolds itself as the boat glides on. The heat during the day is almost unbearable, and it is only when night sets in that any relief is felt and walking made pleasant. The firework displays are on a grand scale, being undertaken by Messrs. Pain and Co., of London. Almost every nation under the sun is represented in the motley crowds that swarm about, and it is most interesting from some vantage ground to watch the curious sights and incidences that will continually present themselves to a sharp observer of human oddities.

Mr. Fell went out primarily on business for his firm—the Laing, Wharton, and Down Construction Syndicate—and was employed in testing, at the works of the General Electric Company of America, the two 350-kilowatt direct-driven alternators which his firm are about to instal in the new station of the City of London Electric Light Company at Bankside. The writer was given to understand that these machines possess many important improvements in construction, details of which he soon hopes to be in a position to publish, as they will doubtless prove of great interest to central station men. The electrical efficiency of these machines is reputed to be extremely high, and from a low load of one-eighth to the full load, a higher efficiency is claimed than any other machine of similar type.

The work at Niagara is progressing very slowly. Although the main tunnel is cut out, it has yet to be lined, and the basin for receiving the water at the head of the tunnel is not yet built.

During a short stay in New York, some interesting information concerning central-station work was picked up. The central station engineers there seem to have very advanced views respecting economy—as an example, in the new Edison station no less a boiler pressure than 250lb. per square inch is used. A great deal of the steam-piping is made of copper, and where wrought iron is used, the flanges are 3½in. thick. The engineer-in-charge stated that now they never put in steam-piping in duplicate, because they have the most implicit confidence in their own distributing methods, and he quite laughed at the writer's friend when he mildly ventured to state that he thought it advisable to always use a ring system of piping wherever possible. One half of this station is to be worked by triple-expansion engines, and the other half by quadruple-expansion engines; but, perhaps, the most striking feature in the whole station is that concerning the economy of heat: every breath of hot air is taken up through chambers inside the station, passed through the main smoke-stack, and so returned to the fire-box of the boilers. The air thus supplied to the boilers is at a temperature of 300deg. F., thus saving the heat energy that otherwise would have been wasted in raising the air to that temperature.

THE CITY AND SOUTH LONDON RAILWAY CARRIAGES.

Notice has already been taken in these columns (see the *Electrical Engineer* of February 3, 1893) of the special features which differentiate the rolling-stock used on the new underground from that which is customary on ordinary surface lines: and reference was then made to the strong resemblance between the South London carriages and the usual type of tramcar with inside seats running lengthways as opposed to the transverse seats of a railway compartment. In this respect, and in the absence of any class distinction, the South London line therefore is on a level with the democratic street tramway.

Since it is more than likely that a number of other electric lines—whether underground, on the surface, or elevated—will be, as regards many of their details, modelled upon the most successful features of the South London Railway, considerable interest will therefore attach to any account which may illustrate or represent in a new light its chief characteristics, and hence the publication of this brief article, together with some engravings from photographs not as yet made public.

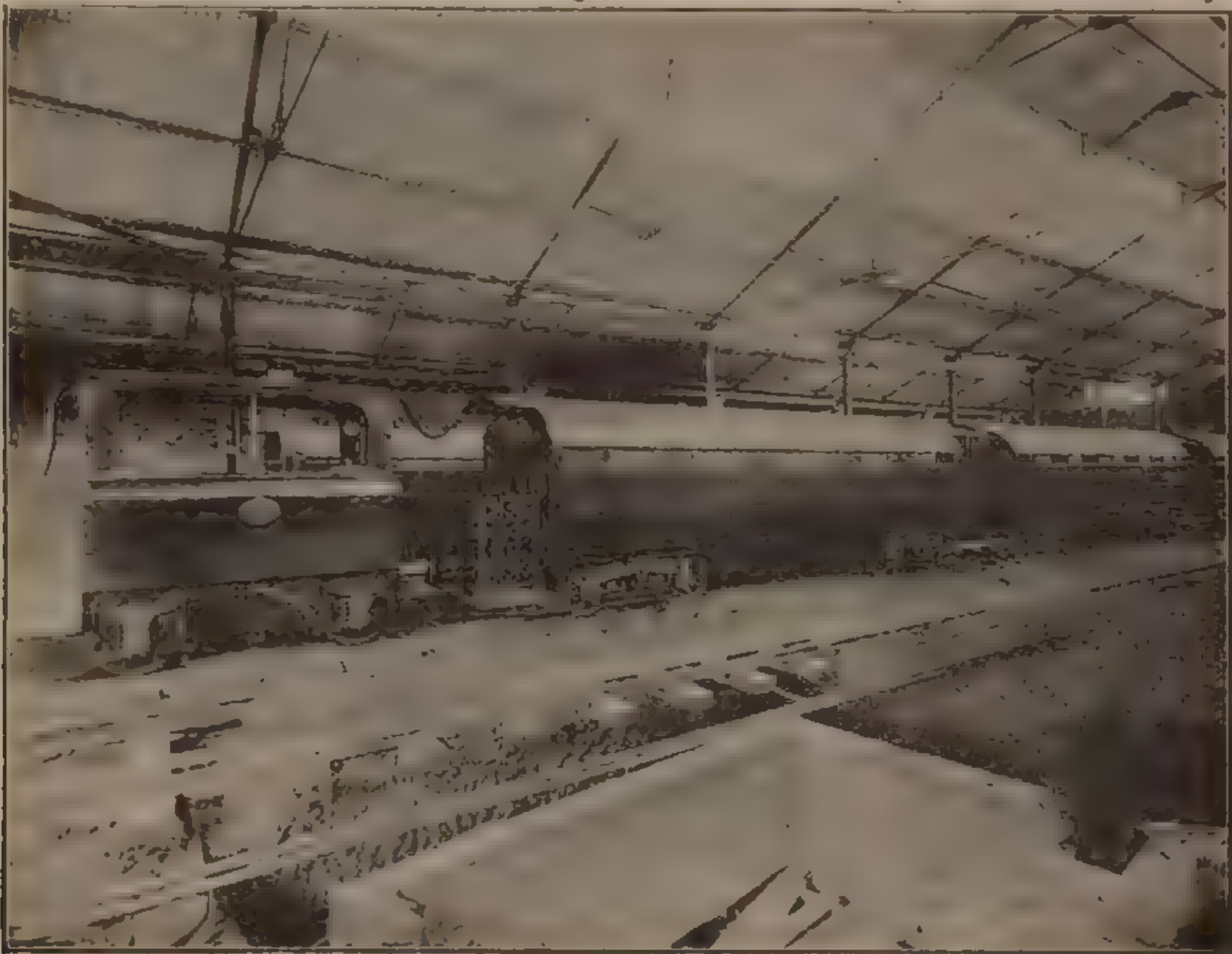
The general aspect of a train upon the South London line will be quite familiar to anyone who has even once travelled on it, but there are many at a distance without opportunities of an inspection, whose interest, however, is keen, and for whose benefit may be set forth the facts. Each train is composed of three carriages and a locomotive: the latter have already been described at length, both when the line was opened and at various times since. Our sole concern is at present with the carriages.

These are each carried on two four-wheeled bogie trucks, and are so connected together that a movable platform carried by the bogie frame swings between each pair of carriages, being independent, therefore, of the carriage frames or bodies. These platforms are covered with a sheet-iron canopy overhead, carried on four pillars of steel rod, and are fitted at the sides with Bostwick collapsible gates.

Down the centre of each carriage runs a passage, and doors are fitted at each end, made to slide in two halves, so that although the carriages make up what is practically a vestibule train, yet each one may be—and is, when running—separated from the others by closing the doors. Passengers are not allowed to stand upon the end platforms while the train is in motion, a guard, or conductor, being put in charge of each platform to open and close the end and side doors as required.

The carriages—as may be seen from the annexed engraving—are each divided in the centre by a transverse partition, with an open archway the full width of the central passage, but without doors of any kind. This arrangement gives the impression of a double carriage, or two compartments. As already stated, the seats are placed longitudinally on each side, and are upholstered both on the seats and backs. Above the back of the seats there are fitted into the side of the carriages ornamental glass panels and mirrors. Four incandescent lamps, supplied with current from the main circuit, serve to light the interior of each carriage, oil lamps being also provided in case of emergency, and for use when the current from the line conductor is momentarily cut off.

Strong representations ought in this respect, however, to be made to the railway company in order to obtain some improvement in the carriage-lighting. The line voltage varies, of course, very considerably, and the incandescent lamps accordingly are found to flicker, greatly to the annoyance of passengers. Some arrangement might very easily—and should—be made for the employment of storage batteries of small size and light weight for illuminating the carriage interiors. These could be carried either on the locomotives or on the bogie platforms, or else underneath the carriage seats; and upon an electric railway one ought at the very least to expect lighting



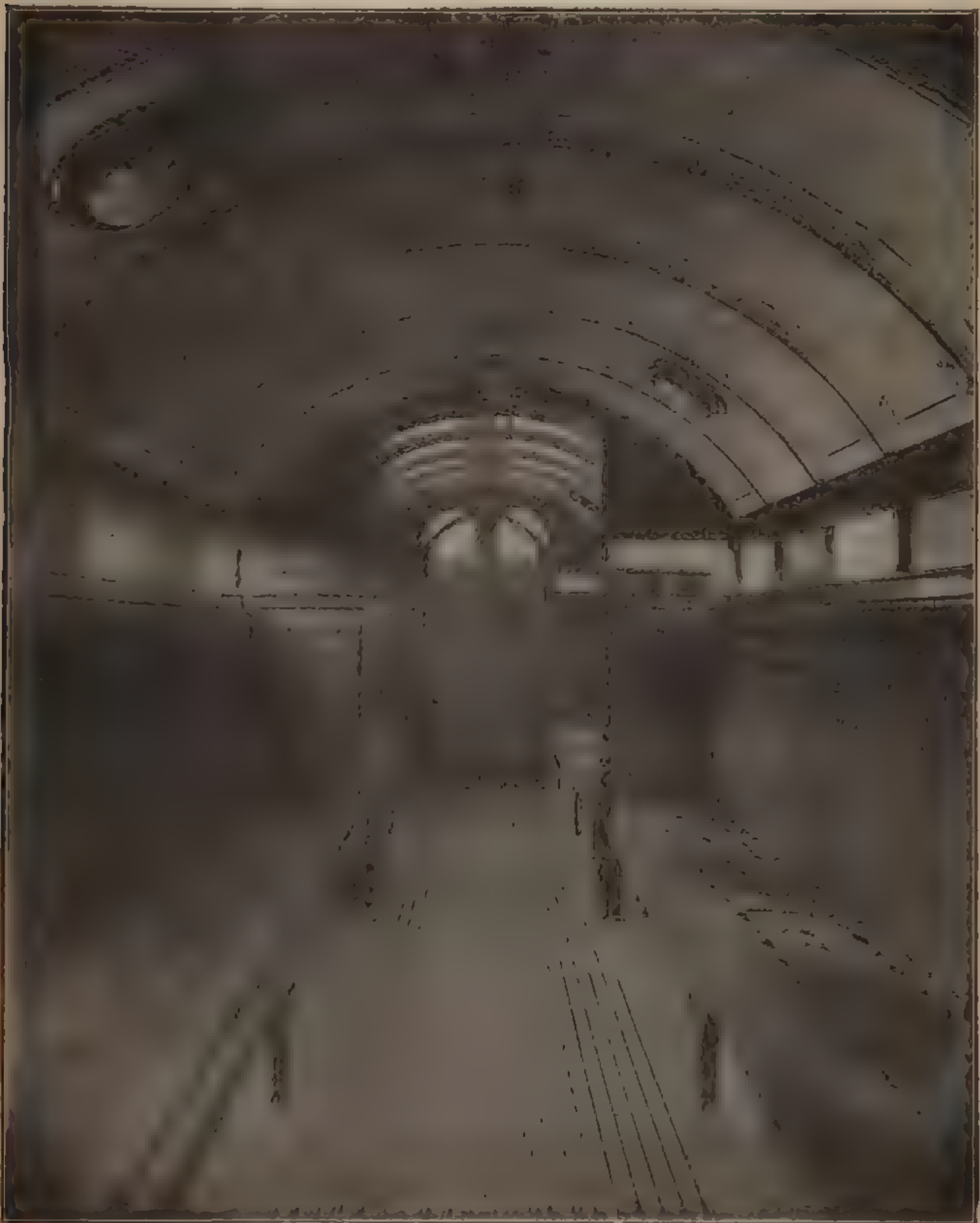
View of Complete Train—City and South London Railway.

capacity as good as may be seen in any of the London omnibuses or tramcars, where small storage cells and incandescent lamps have come increasingly into service.

The carriages are each 26ft. long over the body framing, and the width is 6ft. 10in.—the line being of standard gauge. The height from rail-level to crown of roof is 8ft. 1½in.

scantlings and panels; yellow pine for the roof, floor, and inside casing. Hair felt is inserted under the floorboards and in the sides of the carriage to deaden the noise.

The bogie wheels are 2ft. diameter, and have Bessemer steel tyres and axles; the centres, or hubs, are of wrought iron, Moulmein teak sections being built up to form the wheel body and rim, after the well-known plan adopted by



View of Interior of Carriage City and South London Railway.

The whole of the framework of the bogies is of steel, and so also is the main frame of the body. The side portion of the main underframe is made of a girder in a shape somewhat like the following, in order to allow of the bogies swinging round on a curve.

In the construction of the body the principal kinds of timber employed have been Moulmein teak for both

Mansel. Retaining rings of the Mansel type are also used for securing the tyres to the rims.

The axle-boxes are fitted with oil lubricators, and provided with patent dust shields. Westinghouse automatic air-brakes are used throughout the trains, being operated with air from reservoirs carried upon the trains, and filled when necessary at the termini from large stationary

reservoirs, in which the air is stored at a pressure of 80lb. The quantity carried on each train is usually enough for 30 stops from full speed.

With a full complement of passengers, the average weight of the three carriages which make up a single train may be taken at about 20 tons. The original specifications called for a weight of 4½ tons for each carriage, but this was unavoidably increased to six tons or over. The illustrations that accompany these few details of the South London carriages represent a complete train and the interior of a carriage respectively. For their use, and for the principal facts given in this article, acknowledgment is due to the Ashbury Railway Carriage and Iron Company, Limited, who have built all the 25 carriages constituting the railway company's rolling-stock. F. B. L

COMPENSATORS FOR FALL OF PRESSURE IN FEEDERS FOR DERBY ELECTRIC LIGHTING STATION, MIDLAND RAILWAY.

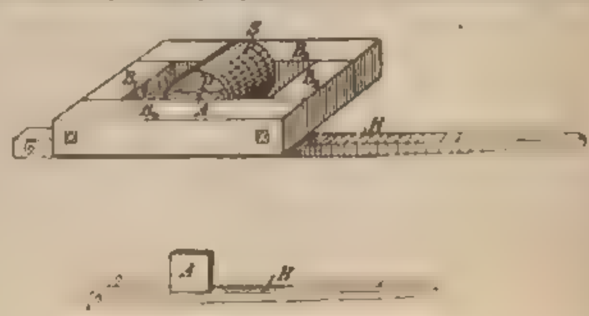
The illustration is taken from a photo of a new compensator for fall of pressure in feeders, constructed on Sayers's new principle by Messrs. Mavor and Coulson, of Glasgow. The compensators have been designed by Mr. W. B. Sayers and his brother, Mr. J. Sayers, of Derby, to keep the pressure constant at the distant ends of the feeders in a low-pressure three-wire system. They will be placed in the engine-room, the current to the feeders which they control passing through them, by which means the pressure is automatically raised by an amount just sufficient to compensate for the drop in the feeders with whatever current may be flowing, thus dispensing with hand regulators and also the necessity for pilot wires.

The compensators proper consist of a pair of low-tension series characteristic dynamos, mounted on the same shaft and driven direct by a motor at a constant speed. The current to the extreme positive feeder traverses one of the armatures of the compensators, and that to the extreme negative feeders traverses the other armature, and the current to each feeder in so doing produces a magnetic flux proportional to itself through the armature and keepers, which form magnetic circuits. The magnetic induction reacts on the winding of the armature, causing an addition of pressure also proportional to the current passing, adjustments being made so that the amount of the added pressure exactly compensates for the drop in the feeders. The manner in which this result is obtained is described in detail in Mr. Sayers's paper recently read before the Institution of Electrical Engineers on the "Prevention of Sparking, etc." In order to compensate for the drop of pressure in the third or centre wire when a current is flowing in it, this current is led around the respective keepers in such a manner as to compensate exactly for the disturbance, which is caused by the drop when a balancing current flows, owing to the two sides being unequally loaded. This is a most important feature, as all engineers who have experience with the problem of keeping pressure constant in a three-wire system will agree. We are unable to describe in detail the way in which this result is obtained, as the patenting process is not yet complete. Two sets of compensators have been constructed for the Derby station—one to carry a maximum current of 500 amperes, and to raise the pressure in the proportion of one volt for every 95 amperes of current flowing, and one to carry a current of 400 amperes and to raise the pressure in the proportion of one volt for every 55 amperes. In each case the third-wire arrangement is adapted for the two outer conductors of the three wire system, each having a sectional area twice that of the central conductors.

SIMPLE APPARATUS FOR COMPARING THE MAGNETIC PROPERTIES OF DIFFERENT KINDS OF IRON.*

BY DR. BEHN-ESCHENBURG, OERLIKON.

This apparatus serves the purpose of comparing different kinds of iron with regard to the strength of the total and residual magnetism with given magnetising forces. The apparatus consists of a right-angled frame of four wrought-iron pieces or blocks, B_1, B_2, B_3, B_4, screwed one to the other; a coil, S, for magnetising; the piece to be tested, P, placed in the coil and screwed to the block B_3; and a wrought-iron plate, A, which fits in exactly between the piece, P, and the block B_4, and may be pushed up by the lever, H, in the direction perpendicular to the block B_4, so that it may be easily adjusted or taken out of contact with P.



Figs. 1 and 2.

There are a few turns of thin wire round the plate, A, and the ends of these may be joined with a ballistic galvanometer. If a current be sent through the coil, S, then B_1, B_2, B_3, B_4, with P and A, form a magnetic double ring. All the lines of force that go through P must also go through A; if, then, with a given strength magnetisation, this plate be

* Abstracted from the *Elektrotechnische Zeitschrift*.

entirely taken out of the magnetic circuit, so that it does not cut any of the lines of force passing through the test piece, it follows that the induction effect upon the wire round the plate will give a measure of the total number, Z, of lines of force which in closed magnetic circuit go through the test piece, P.

Now, if the magnetising current of the coil, S, be interrupted, with closed circuit, there will remain Z lines of force of residuary magnetism, which can similarly be measured by sliding the plate, A, out of the circuit. And if the plate be again placed in position, the magnetising current being interrupted, a measure can be obtained for the lines of force which are still residuary in the iron ring. These lines of force are found to be so few that they may be taken into account only for checking and correction purposes. All the pieces tested by Dr. Behn-Eschenburg were parallelopiped in form, the length being 25cm., and the cross section 81 square centimetres. The plate, A, was 1cm. thick, and its cross-section, as also that of the pieces $B_1 \ldots B_6$, equal to that of the test piece. The coil had 300 turns, in several sections. The current was produced by an accumulator battery. The strength of the current was measured by a Siemens dynamometer. All sources of error from self-induction, etc., were eliminated.

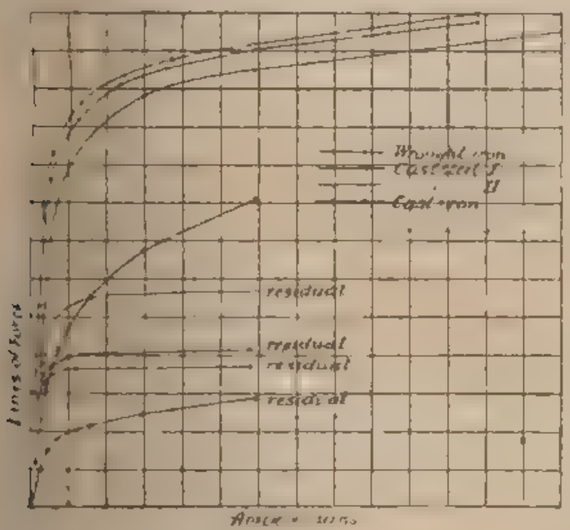


Fig. 3.

The experiments referred to six kinds of iron: (1) wrought iron, (2) Pilsen cast steel, (3) Remscheid I. cast steel, (4) Remscheid II. cast steel, (5) Belgian cast steel, (6) cast iron. The curve for wrought iron was taken as normal. In the curve, diagram 3, only the curves for two kinds of cast steel are shown, the other curves lying between them. The conditions of the experiments were varied as to increase and decrease of the magnetising force, and the results for a given magnetising force agreed remarkably well in repeated tests. The experiments showed that the number of measured lines of force with closed magnetic circuit was greater at the moment of forming the magnetising current than at its cessation, and that the difference increased with increasing ampere-turns, and was greatest where the residual magnetism was greatest. The magnetisation of the iron was continued up to saturation.

Finally, it may be mention that the lever used in the experiments was about three metres long and 5cm. thick, and that a considerable pull, corresponding to about 30kg (66lb.), was required in some of the tests to cause the plate to slide out of the magnetic circuit.

ELECTRIC LIGHTING PROVISIONAL ORDERS AND LICENSES.

REPORT BY THE BOARD OF TRADE RESPECTING THE APPLICATIONS TO AND PROCEEDINGS OF THE BOARD OF TRADE UNDER THE ELECTRIC LIGHTING ACTS DURING THE PAST YEAR.

The following applications for provisional orders have been received by the Board of Trade since the date of the last report.

Title of Order and Description of Area	Name of Promoters.
Altrincham and Bowdon Electric Lighting Order. The Local Board Districts of Altrincham and Bowdon and a portion of the District of the Rural Sanitary Authority for the Altrincham Union	Manchester Edison-Swan Company, Limited.
Barnet Local Board Electric Lighting Order. The District of the Local Board.	The Local Board.
Beckenham Electric Lighting Order. A portion of the Parish of Beckenham	Do.
Bridgend Electric Lighting Order. The Urban Sanitary District of Bridgend.	Do.
Brighton Electric Supply Order. The Municipal Borough of Brighton.	Brighton and Hove Electric Light Company, Limited.
Colchester Electric Lighting Order. The Borough of Colchester.	Corporation.
Eccles Electric Lighting Order. Municipal Borough of Eccles.	Do.
The County of London:	
Hackney Electric Lighting Order. The District of the Board of Works for the Hackney District.	The Board of Works.
Hammersmith Electric Lighting Order. The Parish of Hammersmith.	The Vestry.
Islington Electric Lighting Order. The Parish of St. Mary, Islington.	Do.
Islington Electric Lighting Order. The Parish of St. Mary, Islington.	County of London Electric Lighting Company, Limited.
Poplar District Electric Lighting Order. The District of the Board of Works for the Poplar District.	The Board of Works.
St. Mary, Islington (North) Electricity Supply Order. A portion of the Parish of St. Mary, Islington.	Holloway Electricity Supply Company, Limited.
Newcastle upon Tyne Electric Lighting Order. The City and County of Newcastle upon Tyne.	Newcastle upon Tyne Electric Supply Company, Limited.
Newmarket Electric Lighting Order. The Urban Sanitary District of Newmarket.	British Electric Light Company, Limited.
Partick Electric Lighting Order. The Burgh of Partick	The Commissioners of Police.
Reading Electric Supply Order. The Borough of Reading.	Reading Electric Supply Company, Limited.
Taunton (Corporation) Electric Lighting Order. The Municipal Borough of Taunton and a portion of the District of the Taunton Union Rural Sanitary Authority.	Corporation.

Of these applications (18 in number) 11 were made by local authorities, and seven by companies, while six related to the county of London.

In one instance an application was received from the local authority, and another application from a company, for the same area and a second company applied for an order in respect of a portion of that area. An order was granted to the local authority, and the applications of the companies were refused.

The following statement shows the manner in which the various applications have been dealt with:

Title of Order.	How dealt with.
Altrincham and Bowdon Electric Lighting Order.	Order granted.
Brighton Electric Supply Order	The promoters failed to produce the consent of the local authority, and the Board of Trade directed that a local enquiry should be held. After consideration of the report made by the inspectors appointed to hold the enquiry, the Board of Trade were of opinion that no reasons had been advanced sufficient to justify them in dispensing with the consent of the local authority, and refused to grant the order. The local authority are themselves supplying electrical energy under a provisional order obtained in 1883.
Barnet Local Board Electric Lighting Order.	Order granted.

Title of Order.	How dealt with.
Beckenham Electric Lighting Order.	Order granted.
Bridgend Electric Lighting Order.	Do.
Colchester Electric Lighting Order.	Do.
Eccles Electric Lighting Order.	Do.
The County of London:	
Hackney Electric Lighting Order.	Do.
Hammersmith Electric Lighting Order	Do.
Islington Electric Lighting Order (Vestry).	Do.
Islington Electric Lighting Order (County of London Electric Lighting Company, Limited)	An order was granted to the Vestry, and this application was refused
Poplar District Electric Lighting Order.	Order granted.
St. Mary, Islington (North) Electricity Supply Order.	An order was granted to the Vestry, and this application was refused.
Newcastle upon-Tyne Electric Lighting Order.	Order granted.
Newmarket Electric Lighting Order	The promoters failed to produce the formal consent of the local authority, and the Board of Trade, for the reasons stated in the special report made by them and presented to Parliament, decided to dispense with the consent of the local authority, and granted the order.
Partick Electric Lighting Order	Order granted.
Reading Electric Supply Order	Do.
Taunton Corporation Electric Lighting Order.	Do.

Bills Nos. 1, 2, 3, 4, and 7, to confirm the orders relating to Altrincham and Bowdon, Barnet, Beckenham, Bridgend, Colchester, Eccles, Hackney, Hammersmith Poplar, Newcastle upon Tyne, Newmarket, Partick, and Taunton, were introduced into the House of Commons on the following dates viz.: Nos 1 and 2 on the 29th March, Nos. 3 and 4 on the 25th April, and No 7 on the 30th May.

Bills Nos 5 and 6, to confirm the orders relating to Reading and Islington, were introduced into the House of Lords on the 8th May.

Bills Nos 2 and 3 received Royal assent on the 9th June. Bills Nos 1 and 4 to 7 are still before Parliament.

The Bills to confirm provisional orders granted by the Board of Trade last year, which were before Parliament at the date of last report, all received Royal assent.

In the following instances the Board of Trade have approved deeds transferring to limited companies the powers, duties, and liabilities (with certain exceptions) under provisional orders granted to local authorities

Title of Order.	Originally granted to.	Transferred to.
The Cambridge Electric Lighting Order, 1890.	The Corporation of Cambridge.	The Cambridge Electric Supply Company, Limited.
The Hove Electric Lighting Order, 1890.	The Hove Commissioners.	The Hove Electric Lighting Company, Limited.

LICENSES.

The following applications for licenses have been received since the date of the last report, and have been dealt with in the manner shown below:

Local Authority or Company applying, and District.	How dealt with.
Crystal Palace Electric Supply Company Limited. (Portions of the following districts:- viz. Parishes of Lambeth and Camberwell Districts of the Lewisham District Board of Works and of the Beckenham Local Board, and Borough of Croydon	Still under consideration.
Pontypool Electric Light and Power Company, Limited. (District of the Pontypool Local Government Board.)	License granted Jan. 21, 1893.
The Corporation of Taunton. (The Municipal Borough of Taunton.)	License granted Feb. 3, 1893

Of the applications for licenses referred to in the last report, that of the Ogmore Valley Electric Light and Power Supply Company, Limited, was granted on September 16, 1892. The others are still under consideration.

Appended is a list of the provisional orders confirmed by Parliament (prior to the present session), and of the licenses granted by the Board of Trade since the passing of the Electric Lighting Act, 1882, showing those which have since been revoked or repealed.

Board of Trade, June 27, 1893. COURTENAY BOYLE.

COMPANIES' REPORTS.

NATIONAL TELEPHONE COMPANY, LIMITED.

President: James Staats Forbes. Vice president: Right Hon. Lord Balfour of Burleigh. Directors: Chas. Swain Agnew, George Franklin, Eli Heyworth, Colonel Robert Raynsford Jackson, William Cuthbert Quilter, M.P., George Hunter Robertson, Sir Albert Kaye Rollit, M.P., Samuel Herrick Sands, William Alexander Smith, Alderman Joseph Thompson. General manager: Wm. E. L. Gaine. Secretary: Albert Anns.

Report of the Directors for the year ending April 30, 1893, to be presented to the shareholders at the thirteenth ordinary general meeting of the Company, to be held at the City Terminus Hotel, Cannon street, E.C., on Tuesday, July 18, 1893, at 1 p.m.

The income accrued in respect of the business of the year amounts to £583,590. 2s 11d., as compared with £463,741. 5s. 4d. for the preceding year, being an increase of £119,848. 17s. 7d. The rentals carried forward this year for unexpired terms of running contracts amount to £285,020. 7s 8d as compared with £234,370. 11s 2d for the preceding year, or an increase of £50 649. 16s. 6d. The working expenses and other charges (excluding debenture and other interest) amount to £311,644 10s. 2d., as compared with £236,252. 0s. 5d for the preceding year, being an increase of £75,392 9s 9d. The net result for the year, after deducting the Post Office royalties amounting to £54,220 9s. 10d. is a profit balance of £217 725 2s. 11d., as compared with a balance of £187 249 19s 3d for the preceding year, being an increase of £30,475. 3s 8d. Out of the available balance an interim dividend at the rate of 6 per cent. per annum on the first and second preference shares, and 5 per cent. per annum on the third preference and ordinary shares has already been paid. The Board will recommend a further payment at the rate of 6 per cent. per annum on the first and second preference shares, and 5 per cent. per annum on the third preference and ordinary shares, making the dividend for the year 6 per cent. on the first and second preference shares, 5 per cent. on the third preference shares and 5 per cent. on the ordinary shares. The distribution on the ordinary shares of 1 per cent. less than in the preceding year is recommended by the Board chiefly in view of the desirability of strengthening the position of the Company by carrying an adequate annual sum to the reserve fund. The Board propose, under No. 113 of the articles of association, to transfer to the reserve fund £30,000 (bringing that fund up to £134,027 3s. 6d.), and to carry forward the balance of £2,194 14s 3d. A reference to the capital account shows that during the year the purchase has been completed of the undertakings of the Western Counties and South Wales Company, the Sheffield Company, and several other minor companies. Though involving the outlay of £345,776, the Board believe that these purchases will be advantageous alike to the public and the shareholders as enabling the telephone business of the country to be developed and conducted more efficiently and economically than it could possibly be if carried on in a disjointed fashion by a number of small and separate administrations. Since the end of the past financial year arrangements have been made for acquiring the Telephone Company of Ireland. The Board have had to consider their position in relation to the New Telephone Company, which was launched in avowed competition with the National Company. The promoters of that enterprise soon began to appreciate the serious difficulties which lay before them, and as the result of discussion, accepted the conclusion that if the shareholders were to be secured a reasonable return upon their capital it would be better in the public interest to work in harmony with the National Company, adopting as far as practicable the better features of the two systems. This resulted in an agreement under which the National Company subscribed one-third of the capital of the New Company, and were represented on the Board of that company. Subsequently it became apparent that the policy of the Government in assuming possession of the trunk wires, forming the inter-town communication of the country, would greatly complicate the position of the licensed companies, and make unity of administration and interest essential to efficiency and success; therefore, upon the sudden death of the late Duke of Marlborough, who was the enthusiastic and moving spirit of the New Company, those who were associated with him recognised the necessity of still closer union with the National Company, and matters have ended in the National Company acquiring, partly by purchase and partly by the exchange of New Company's shares for National shares, nearly the entire interest in the New Company. During the year negotiations of a difficult and complicated character in relation to the acquisition by the Government of the Company's trunk lines have been carried on with the authorities of the Post Office. The Board are gratified to be able to report that a draft agreement is now in course of preparation, which it is hoped may be shortly accepted and ratified by the contracting parties. The rapid growth of the Company's business, and the expansion of its territory consequent upon the absorption of the several minor companies, coupled with the increasing responsibilities of the Board involved in the closer relations with the Post Office, pointed to the importance of bringing into the counsels of the Company some new members of a certain public position and experience. This necessity was unanimously recognised, and acting in the spirit that no question of personal interest should stand in the way of the interest of the shareholders two vacancies were created by the voluntary retirement of Mr. John Bruce and Mr. Peter Garnett. The Board, under the powers conferred on them by the articles, were enabled to fill up these vacancies by the election of Lord Balfour of Burleigh and of Sir Albert K. Rollit, M.P. The same spirit

which actuated his two colleagues was displayed by Colonel R. Raynsford Jackson, who readily vacated his position as vice-president of the Company in order that it might be filled by Lord Balfour of Burleigh, whom it was considered desirable to place in that important office. At the general meeting four Directors retire, and being eligible offer themselves for re-election, viz., Lord Balfour of Burleigh, Mr. Charles Swain Agnew, Mr. George Hunter Robertson, and Sir Albert Kaye Rollit, M.P. Lord Balfour of Burleigh and Sir Albert Kaye Rollit, M.P., elected to retire, considering it would be respectful to the shareholders to submit their recent selection by the Board to the judgment of the proprietors. The auditors, Messrs. Welton, Jones, and Co., also retire, and are eligible for re-election.

AUTHORISED CAPITAL.

15,000 6 per cent. first preference shares of £10 each	£150,000
15,000 6 per cent. second preference shares of £10 each	150,000
250,000 5 per cent. third preference shares of £5 each	1,250,000
490,000 ordinary shares of £5 each	2,450,000
	£4,000,000

REVENUE ACCOUNT FOR THE YEAR ENDING APRIL 30, 1893.

	£	s.	d.
Expenses—			
Rents of premises, taxes, and insurance	35,916	7	4
Working expenses for management, Directors' fees, operators' wages, office salaries and charges	168,666	9	5
Maintenance and renewal of lines and instruments	101,108	4	1
	305,691	0	10
Balance, being profit carried to net revenue account	221,218	11	10
	£526,909	12	8

	£	s.	d.
Subscriptions and rentals—			
Brought forward from last account	234,370	11	2
Do. Western Counties and South Wales Telephone Company, Limited, May 1, 1892	17,571	14	6
Received and outstanding	614,208	4	6
	866,150	10	2
Less proportion of subscriptions and rentals in respect of periods extending beyond April 30, 1893	285,020	7	8
Accrued for the year	581,130	2	6
Deduct Post Office royalty	54,220	9	10
	£526,909	12	8

BALANCE SHEET, APRIL 30, 1893.

				£	s.	d.
Revenue account, 1893-94—						
Proportions of subscriptions and rentals in respect of periods extending beyond April 30, 1893				285,020	7	8
Less amount paid in advance for Post Office royalty				26,087	10	5
				258,932	17	3
Amounts advanced by bankers				70,000	0	0
Amount advanced by New Telephone Company, Limited				120,000	0	0
Sundry creditors				74,120	9	6
Reserve fund				104,627	3	6
Net revenue account—balance at credit	£181,562	7	1			
Less interim dividend paid for half-year ending October 31, 1892	68,863	0	2			
				112,699	6	11
				£740,379	17	2

	£	s.	d.
Capital account—			
Balance as per statement	19,608	15	0
Stock of materials on hand at head office and branches	149,283	14	7
Office furniture and fittings on hand at head office and branches	14,908	2	1
Debtors for outstanding rentals	74,842	5	9
Sundry debtor balances	10,987	3	11
Shares in other companies—ordinary shares in the Telephone Company of Ireland, Limited	21,875	0	0
Subscriptions to other companies—shares in the New Telephone Company, Limited	397,580	18	6
Land, buildings, and machinery	17,964	1	9
Cash at head office and branches, in bank, and on hand	33,329	15	7
	£740,379	17	2

Lamina Accumulator Elieson's British Patents' Syndicate, Limited.—This Company has been registered by Bullock, Bourner, and Thomson, 10, Throgmorton avenue, E.C., with a capital of £12,000 in £1 shares. Object: to carry into effect an agreement for the acquisition of certain patents relating to improvements in electric accumulators or storage batteries, and to develop and turn to account the same, and to carry on business as electricians and electric engineers generally. Table A mainly applies.

BUSINESS NOTES.

West Hartlepool.—This Town Council have appointed a committee to consider the price of gas in the town, which is held to be excessive.

Bombay.—The Bombay Municipality have renewed their gas contract for a year only from July. They wish to test the Welsbach and other burners.

Bolton.—The Bolton Corporation invite tenders for alternators and dynamos for their central station. Particulars will be found in our advertisement columns.

Liverpool Overhead Railway.—For the convenience of visitors to the sands at Seaforth a special late service of trains is being run on the Liverpool Electric Railway.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting 17 per cent. payable to the London Platino Brazilian Company, were £2,372.

Worcester City Council.—The note last week headed "Birmingham" was by error attributed to this Town Council, whereas it should have referred to the Worcester City Council.

Croydon.—The Croydon County Council have resolved, subject to the sanction of the Local Government Board, to adopt the electric light in the centre of the borough, at an estimated cost of £25,000.

Caledonian Electric Supply Company, Limited.—This Company has been established with a nominal capital of £100, divided into 100 shares of £1 each. The registered office of the Company is in Edinburgh.

St. James's and Pall Mall Electric Light Company, Limited.—The Directors have declared an interim dividend for the half year ending June 30, 1893, at the rate of 7 per cent. per annum on the preference shares.

Portsmouth.—The tender of the International Electric Subway Company for electric mains for Portsmouth has been accepted, and the Johnstone system, which is the specialty of this company, will be laid throughout.

Appointment.—The Huddersfield Electric Lighting Committee require the services of an assistant electrical engineer accustomed to high-tension alternate-current working. Application by the 24th inst. to the Town Clerk, Huddersfield.

Personal.—Mr. Claude W. Hill, A.M.I.C.E., has been manager of Messrs. Paterson and Cooper's works, Pownall road, Dalston, since July last. Letters to him should be addressed there, and not to his late address—5, Parsonage, Manchester.

City and South London Railway Company.—The receipts for the week ending July 9 were £1,069, against £733 for the same period last year, or an increase of £336. The total receipts for the second half-year of 1893 show an increase of £336 over those for the corresponding period of 1892.

Tunbridge Wells.—At the monthly meeting of the Town Council last week, Alderman Clifford, on behalf of the Electric Light Committee, again brought forward the proposal to adopt electric light for Tunbridge Wells at an outlay of £13,000. On a show of hands the committee's report was adopted by 16 votes to 9.

British Museum.—The new arrangements for the lighting of the British Museum reading room will allow of the setting up of nearly 200 lights, and it is expected that everything will be fitted for the use of the new illuminant not later than the middle of August, or some weeks before the commencement of the next season.

Tiverton.—At the Tiverton Town Council last week, it was reported that Sir Thomas Bloomfield, the head of the Electrical Department of the Board of Trade, would advise the Board to extend for one year the powers of the provisional order for the supply of electric light in the town, which was considered satisfactory.

Eastbourne Parade.—At the Eastbourne Town Council meeting last week Alderman Homewood moved, Councillor Martin seconded, and it was resolved: "That the common seal be affixed to an agreement between the Eastbourne Electric Light Company, Limited, and the Corporation of Eastbourne for lighting the Royal parade by electricity."

Proposed Electric Tramway at Edinburgh.—At the last meeting of the Edinburgh Town Council a letter was submitted on behalf of the Caledonian Electric Supply Company, Limited, with notice, in terms of Section 4, Sub-Section 1 of the Electric Lighting Act, 1882, in connection with proposed electric tramway from Coltbridge to Corstorphine.

Blackpool Lighting.—Councillor Pearson, at the Blackpool Corporation meeting, said he thought the electric supply would be ready about the first week in August, or possibly the second, the whole of the town, as regarded private lighting. He had had interviews with the contractors and Mr. Wolstenholme, and he thought the public would not be disappointed.

Glasgow Municipal Buildings.—The minutes of the Committee on Municipal Buildings of the Glasgow Corporation stated that the sub-committee had authorised the extension of the electric lighting over the whole building with the exception of the basement, the committee room corridor, and Burgh Court Hall. The estimated cost is £2,000. The minute was approved.

Perth.—At the monthly meeting of the Perth Town Council, a letter was read from the Caledonian Electric Supply Company, Limited, stating that application was to be made to the Board of Trade for a provisional order authorising the company to supply electricity within the burgh of Perth, and asking the consent of

the Corporation. The communication was remitted to the Lord Provost's Committee.

Athletic Association.—Mr. Dane Sinclair recently presided at an enthusiastic gathering of the London staff of the National Telephone Company, at which it was decided to form a sports club, to be called "The Telephone Athletic Association." A provisional executive committee was appointed to arrange details, with Mr. T. C. Walker as treasurer and Mr. W. E. Deane as secretary, and a large number of members have already been enrolled.

Whitehaven.—At the monthly meeting of the Whitehaven Town and Harbour Trust the chairman said they would observe the laying of electric mains was progressing but the progress, unfortunately, was not quite so rapid as it ought to be, as the time expired on July 1, and there still remained a good deal of work to be done. Still the work was going on fairly regularly and rapidly, and he expected it would be finished in the course of three weeks.

Sheffield.—The Sheffield Works Sub-Committee in their report, which was adopted by the Highway and Sewerage Committee, have considered the question of the transformer chambers proposed to be constructed by the electric lighting company, and have decided to allow the company to place boxes near the Monolith, in White Bear walk, the Market place, top of East parade, Water lane, Norfolk street, and the junction of Westbar and Spring street.

Morecambe.—At the monthly meeting of the Morecambe Local Board on Tuesday, a memorial was read from property owners in the vicinity of the electric light company's central station complaining strongly of the nuisance caused by the noise of the engines and the smell of exploded gas. The reports of the medical officer and the surveyor on the matter were also read, and it was resolved to forward the whole correspondence on the subject to the Local Government Board, asking if the Board can take the matter up.

Birmingham.—The General Purposes Committee of the Birmingham City Council had under consideration the question whether the Corporation should themselves obtain a provisional order for the supply of the electric light, and consequently oppose the extended order asked for by the Birmingham Electric Supply Company. The consideration was adjourned. The *Daily Post* now states that after long and careful enquiry the committee at their meeting on Monday decided that it would be inadvisable for the Corporation to undertake the supply of electricity, and will report to the Council at its next meeting in that sense.

Arbitration Clause in Contracts.—In a circular sent out by the London Chamber of Commerce on the 17th January last, the text of a clause for use on contracts was incorporated which provided for the reference of all disputes thereunder to the London Chamber of Arbitration. Some objection having been taken to the length of that clause, the matter has been reconsidered, with the result that the council now recommend the use by members of the following stipulation: "All disputes which may arise relating to this contract shall be submitted to arbitration under the rules for the time being of the London Chamber of Arbitration."

Dundee.—At the last meeting of the Dundee Gas Commission a report was submitted from Messrs. Urquhart and Small, consulting electrical engineers, London, stating that the various contracts in connection with the introduction of the electric light into Dundee had been carried out to their satisfaction. Certain alterations had been effected in the matter of details; and it was suggested that the Commission should consider an offer to have the batteries maintained for an annual payment of £80. The Commission expressed approval of the manner in which the installation had been gone about, and it was reported that the installation had cost £19,007. 12s. 7d. This includes £599. 8s. 4d. of extras, or 1·6 per cent. of the total contracts.

Bradford.—At the Bradford Town Council meeting, Mr. James Kay, deputy chairman of the Gas and Electricity Supply Committee, moved, and Mr. George Newby seconded, the adoption of the minutes, which contained particulars of correspondence and interviews with Lord Kelvin as to the mode of extending the electricity supply works, and his Lordship's report was given. It was stated that Lord Kelvin had been invited to meet the committee in Bradford at an early date for the purpose of conferring with them before the course to be taken was determined upon. The minutes included a resolution advancing the salary of Mr. Mitchell, assistant electrical engineer, from £125 to £150 per annum. These parts of the minutes were adopted.

Stafford.—At the Stafford Town Council monthly meeting the committee reported that they had had before them various names of electrical engineers, and recommended that the services of Dr. John Hopkinson, of London, be retained. Alderman W. H. Peach, in moving the adoption of the report, stated that from a list of 12 gentlemen well known in the electrical world the committee selected Dr. John Hopkinson, whose name was very well known in connection with electrical matters. He was the inventor of the three-wire system, and was a man of perhaps greater experience than anyone else whom they could possibly get. At the present time he was engaged in carrying out a large installation for the Manchester Corporation, and also a smaller one for the town of Whitehaven, and the committee felt confident in his giving a satisfactory report. His fee would be 100 guineas, including expenses, and they expected a visit from him during the present week. The report was adopted.

Accrington.—At the meeting of the Accrington Town Council last week, Mr. Riley asked if anything had been heard from the Local Government Board with reference to the borrowing powers for the electric light scheme. It seemed to him that the thing had gone dead altogether. The Town Clerk replied that the matter had not gone dead; but the time of the Legal and Parliamentary Committee had of late been so much occupied with the gas and water question that they had not been able to do anything with regard to the electric light. The Local Government Board had given their sanction to the borrowing of money for the scheme, but it was not a very satisfactory sanction, as the Board had grouped the land, machinery, etc., together, and only offered the Council 25 years for repayment. That was outrageous. They ought to have the same length of time for repayment for the land for the electric light as they had for the baths—50 years—and until they had that he would not recommend the Council to accept the sanction.

Margate Hotels.—The hotel accommodation of Margate has received an important addition in the erection of the Hotel Metropole, a very fine structure facing the jetty and close to the sea, opened on June 24th. It has been erected on the site of the Grand (which was destroyed by fire two years since) and adjacent buildings, and is under the management of a limited liability company, of which Councillor W. Leach Lewis is chairman and Mr. Walter Hills solicitor. It was designed by Mr. Albert Latham, the borough engineer, and built by Mr. Jesse Goldsworthy, and consists of about 120 rooms, which have been elaborately furnished by Messrs. Edwards and Roberts, of Wardour street. Property has also been acquired for the erection of 50 more rooms. Throughout the building the electric light is used. The sitting and other rooms overlook the sea, and the hotel will prove an additional attraction to the town. The sanitary arrangements are perfect, and baths have been provided on each floor.

Politics and the Electric Light.—At the Northampton Town Council Mr. Mills moved the Town Hall Committee's report, which contained a recommendation that the old reading room be cleaned and done up in a plain substantial manner. Mr. Mills said that the cost of doing up the room would be about £18. There was the additional question of fitting the room up with the electric light, and the estimate for that was £30. The committee had just had a meeting and considered the electric light question, but they were not prepared to report. He believed the committee would be glad of an expression of opinion on the part of the Council on that point. A discussion ensued as to which political party were to have the use of the room. Dr. Buzzard then moved that permission be not given for the electric light until a statement had been made and laid before the Council as to the uses to be made of the room when it was renovated and done up, and also the price to be charged for the use of the room. After a little discussion, Dr. Buzzard withdrew the amendment at the suggestion of the Mayor, and the report with the addition of the electric light was then carried.

Eastern Telegraph Company.—The revenue for the half year amounted to £372,852 10s., from which are deducted £102,499 7s. for the ordinary expenses, and £32,532 17s. 11d. for expenditure relating to repairs and renewals of cables, etc., during the half-year. After providing £3,263. 18s. 8d. for income tax, there remains a balance of £234,556. 6s. 5d., to which is added £62,942 4s. 4d. brought from the preceding half year, making a total available balance of £297,498 10s. 9d. From this balance there have been paid interest on debentures and debenture stock £27,801 6s. 3d.; dividend on preference shares, £20,174 1s. 8d.; an interim dividend of 2s. 6d. per share on the ordinary shares, £50,000—£98,365. 1s. 11d.—leaving a balance of £199,133 8s. 10d., from which £88,000 has been carried to general reserve fund. The Directors now recommend the declaration of a final dividend for the year ended March 31, 1893, of 2s. 6d. per share, and a bonus of 3s. per share, amounting together to £110,000, both payable on the 13th inst., free of income tax, and making, with the three previous payments on account, a total distribution of 13s. per share, or 6½ per cent. for the year on the ordinary shares.

Burton.—At the monthly meeting of the Burton Town Council, the Gas and Electric Committee, dealing with the electric lighting arrangements, advised that the charges for the new illuminant should be: for any amount up to 20 units, 10s. per quarter, and for every unit over 20, 6d. per unit—these prices to apply to ordinary customers otherwise than by agreement. In moving the adoption of the report, Alderman Lowe said they were making good progress with the electric light works, and the erection of the building was moving rapidly. The committee had carefully considered the question of charges for the use of the light, and by the Local Government Board regulations the maximum was 8d. per unit, while the minimum price was 5d., but the committee recommended a medium figure—viz., 6d.—feeling convinced that by placing the price at that reasonable sum they would receive a large number of applications. That would make the cost equal to that of gas at 5s. per 1,000 cubic feet. The report was adopted. The Finance Committee had to report that they had received the consent order of the Local Government Board, dated June 16, 1893, authorising the Town Council to create and issue stock for raising £131,641, of which £25,000 was for electric lighting.

Manchester.—Mr. Charles Nickson, superintendent of the Manchester Corporation Electric Light Department, issues a report stating that the central-station buildings are now completed, and the following plant has been fixed in position, viz.: Six steel boilers, steel tank, coaling stage and crane; steam-pipe, six 90-h.p. vertical compound engines, two 350-h.p. vertical compound engines, six dynamos giving 102 volts; two dynamos giving 410 volts; and two travelling cranes. The switch and instrument boards are in course of erection. Over a mile of concrete culvert for mains have been constructed, and about 65

tons of copper strip placed thereon upon porcelain insulators. Two and a half miles of cast iron pipes have been laid, into which six miles of ¾in. and five miles of ⅝in. insulated cable have been drawn. The works are rapidly approaching completion, and it is anticipated that a supply of current will be available by August 1. It appears that of a total authorised loan of £80,000 only £50,200 has yet been borrowed, of which £41,720 has been expended. No administration charges from the gas department are included, but there is £485 charged for engineer's advice. A proportion of administrative charges should be given for comparison with private company working.

Proposed Extension at Leeds. — Although the Yorkshire House to House Electricity Company's works in Whitehall road were opened so recently as May 10 last, the demand for the electric light in the city has proved so large as to necessitate an immediate increase of plant. It has been decided to put down another engine of 250 i.h.p., and a dynamo of corresponding capacity. It is anticipated that the additional plant will be ready for use in the coming winter. This addition, whilst involving an increase in capital expenditure of less than 10 per cent. (owing to the works having been constructed with a view to the allowing of easy and comparatively inexpensive additions), will increase the possible output of electricity no less than 40 per cent. It is expected that the profit earning capabilities of the company will increase in even greater proportion, the cost per unit of electricity naturally diminishing with every increase in production. The extension necessitates the raising of additional capital, and the directors are inviting subscriptions from the existing shareholders for the balance (2,634 shares) remaining unallotted of the first issue of 10,000 ordinary shares of £5 each. The directors hold more than one fifth of the total capital subscribed, and propose to increase their stake in the concern by at least £3,000.

Outing. — A brake outing of the employes of the Bath Electric Light Company and Messrs. Coward and Ihlee took place on Saturday, the place selected being Longleat. In the case of the first named firm it may be mentioned that this is the first outing given to the men since the works were started, and was the outcome of the zeal and interest displayed in the welfare of the men and works generally by the new engineer and manager, Mr. G. F. Metzger, who, in conjunction with Mr. F. C. Ihlee, suggested the idea of the two firms amalgamating for a day's outing. The visit to Longleat House was much enjoyed, and after lunch and sports the return journey was broken at Beckington for a social meeting. Mr. Metzger proposed the health of the directors, who had liberally contributed to the expenses. The toast of the evening was proposed by Mr. W. J. Sheppard, foreman of Messrs. Coward and Ihlee, who asked all present with him to drink success to the Bath Electric Light Company and to their new engineer and manager, Mr. Metzger, whom he was sure, with Mr. Wilson, were working very hard to make their lighting station second to none in the kingdom. Mr. Metzger responded, and in concluding desired all present in their employment to take an interest in this work, when he assured them success would sure to follow. He then proposed the firm of Messrs. Coward and Ihlee, to which Mr. F. C. Ihlee responded and trusted that all present had thoroughly enjoyed themselves. Bath was reached shortly after 11.

Accumulators for Nelson. — At the Nelson Town Council meeting last week the Gas Committee decided "that the tender of Mr. Thomas Barton for the supply of the K type No. 1 of cells made and supplied by the Electrical Power Storage Company, at £1,250, and to execute the necessary works required in conformity with the drawings and all the conditions and stipulations of the specification already issued, be accepted; the works to be completed within two months from date of order, the Electrical Power Storage Company to be responsible for the maintenance and repair of the accumulators for 12 months after fixing." Councillor Little complained that more information should have been given to members of the Council in reference to these electric accumulators than was contained in the minutes. A deputation had been paying a visit to London in reference to the accumulators, and he thought they might have supplied a printed report on the subject. Alderman Hartley said the matter had been before the full Gas Committee, which consisted of 12 members, and had been thoroughly discussed by them, a report having been supplied to them by the deputation of the information they had acquired in London. The resolution that had been passed was a resolution of the Gas Committee and another of the deputation, and was passed on the information supplied by the deputation. Councillor Little maintained that a report of some sort should have been presented to those members of the Council who were not on the Gas Committee, as it was a very important question. Alderman Hartley said any member of the Council could have a copy of the sub-committee's report, which contained all the information Councillor Little asked for. The minutes were passed. The Gas Committee have fixed the charge for a 50 c.p. electric lamp at £2. 10s. a year.

Morley (Yorks.). — At the Morley Town Council on Monday last week the Town Hall Committee presented their minutes as follows: "It was resolved that the Town Hall be lighted by electricity, and that a special committee be appointed to report as to the advisability of obtaining powers for the supply and of making arrangements for lighting the public lamps, and supply electricity to any private person. Mr. Henry Clarke reported that the building of the Town Hall was progressing, but not so fast as he wished. The contractor ought to be induced to set more men on, and thus provide work for the other branches of the trade." Councillor Rhodes said, in moving the confirmation of the minutes, that the committee were unanimous in the recommendation that the Town Hall should be lighted with electricity. Then there was the question as to whether they should put down a plant for the purpose of supplying ratepayers with a light that desired it. A special committee ought to be appointed to give the matter their fullest consideration, and to report as to what it would cost to light the town, and also the Town Hall separately. It was a matter of very great importance. Councillor Sykes said he would second the motion if the mover would leave out the portion "that the Town Hall be lighted by electricity," and add "such committee to report separately as to the cost of lighting the Town Hall and the town." Councillor Rhodes agreed. Alderman Dixon said before long their engines at Churwell would be of no value for pumping water, and it would be a question as to whether they would be of use in a scheme like that mentioned. He considered, however, that the question had come upon them hastily, and it wanted due consideration. Councillor Rhodes remarked that the engines would be of no use for this purpose. The minutes were adopted. The following were appointed a special committee to report on the matter: Aldermen Holton, Schofield, Clough, and Wilkinson; Councillors Rhodes, Scarth, Johnson, Jackson, Scholes, Hirst, and Craven.

Cork Tramways. — A deputation, consisting of the chairman (Mr. W. Roman, solicitor), Mr. J. W. Bourke, solicitor, Mr. R. U. F. Townsend, Mr. M. D. Daly, J.P., attended the meeting of the Cork Town Council on the 7th inst. with reference to the proposed tramway scheme for the city. The Standing Committee of June 7 had recommended that the use of overhead wires in connection with the propulsion of the proposed tramcars in the city by electricity should be sanctioned by Council, and the Council itself had already sanctioned the employment of electricity as a motive power, but on condition of the wires being laid underground. Mr. Farrington said that they should consider the matter well before they should take any action on it. If the wires were to be placed above the ground they might be an obstruction in many cases, such as interfering with the progress of fire escapes in case of fire. The Mayor said that no matter what the Council would decide on the subject the matter should have to go before the Board of Trade and receive their sanction. The Board of Trade would not consent to anything that might prove dangerous to the public safety or detrimental to the their interests. For his own part, he (the Mayor) was entirely in favour of the scheme. By it a large portion of the city would be block paved, and it would further save a great deal of expense. He thought the Council should not impede the company in any way in their project. Mr. Frazer said tramways similar to the proposed one in the city had been constructed in Bristol, Plymouth, and Edinburgh, and one also which extended for over 4,000 miles. The strength of the current of electricity in the proposed tramway system would be only 500 volts, and no danger whatever to the public would arise from it. Of course there had been accidents from time in such cases, but he felt confident that no danger would arise from the construction of tramcars in Cork. The recommendation of the Standing Committee that the wires should be placed overhead was passed unanimously, and Mr. Frazer having expressed his thanks, the deputation withdrew.

Manchester. — Sir J. Harwood, on the motion for the approval of the proceedings of the Gas Committee at the meeting of the Manchester City Council, said that one of the works of which he should be glad to be relieved was coming to a close. For many years he had had to do with the Bill which enabled the Corporation to deal with all companies who wanted to establish electric lighting stations in Manchester, and finally they obtained parliamentary powers to put down an installation themselves. He had been chairman of the committee which dealt with the matter, and he was happy to say that, all being well, next Friday week they would be able to light the gas offices in the Town Hall with electricity, and he was confident that the whole of the buildings would be so lighted during the autumn. For reasons which it would not now be prudent to state, the committee had been prevented from going on with the work in the Town Hall in the way they would very much have desired, but they were doing the best they could. He desired particularly to congratulate the Council upon having succeeded in putting down an installation second to none in the kingdom, and perhaps second to none in the world. They would be able in a fortnight or three weeks to begin supplying electricity over a very large part of the city. Many public buildings would, it was understood, be lighted by electricity. The committee were very much pleased with the efficient way in which the work had been carried out. The dynamos would be turned round this week, and the engines and everything connected with the installation were most beautiful. He wanted to say to the public that it was not intended that to any extent whatever the Corporation should supply fittings for buildings. They intended to supply electricity in the streets precisely in the same way and to the same extent as they supplied gas to-day. The only exception was in the matter of meters. The committee would supply meters. As regarded those meters he unhesitatingly said that they were very expensive and not satisfactory, and at any day they might be superseded by something that was satisfactory. They hoped the day was near when the scientific men who were trying to find a meter that would be much more reliable than those now in use would be successful. The minutes of the committee were passed.

Telephones and Electric Traction. — With the exception of those in the electrical industry, and interested parties generally, few people are aware, says the *Pall Mall Gazette*, what important issues are bound up in the report which Lord Cross's joint committee is now discussing in private. For years past the National Telephone Company, which works under license from the Post Office, has applied for the insertion in all Tramway Bills of a clause securing its lines against disturbance from earth leakage or elec-

trical induction in the event of electricity being used as a motive power for the tramways. The telephone is such an extremely delicate instrument and the system of earth return which the National Company still uses affords such facilities for disturbance, that the protection clauses, as worded, are claimed by many to have been almost prohibitive to the development of electric traction in England. It is between these two great interests—electric traction and the telephone—that the settlement really lies though the question has been complicated by other issues affecting the disturbance of railway signals, corrosion of water pipes, etc. If the committee appointed at the instance of the Board of Trade to decide upon the matter give their opinion in favour of the traction companies, a very marked change in the external conditions of our streets and cities may be looked for in a few years. Omitting all discussion as to the possible merits of different systems of electric traction, there is only one which at the present day has made its way to any large extent. This is the overhead trolley system, which is being worked on many hundreds of miles of road in America, and is being continually extended at an enormous rate. Two specimens only are to be seen in England—at Leeds and at Walsall respectively—in both of which places disturbances have arisen, either as regards the telephone company or the railway companies. But the general testimony of the public is so strongly in favour of lines of this class, which are clean, swift, and free from all the horrors of maimed and struggling animals which now disgrace our streets, that one cannot help but hope for a change in the legislation affecting electrical powers which shall make their introduction financially possible. With the impetus thus given to electric traction generally, there is little doubt that isolated vehicles of a more modern and graceful type would rapidly supersede the antiquated "growler" and the frisky hansom which pervade our streets.

Aberdeen Northern Co-operative Company.—A meeting of the shareholders of the Northern Co-operative Company was held last week at Aberdeen specially to consider the question of mechanical heating and electric lighting of the Company's central premises. The chairman (Mr. Jas. Doig) read the requisition of the 24 shareholders to consider these schemes which had been resolved upon by the directors, and which they (the signatories) "feared the expense would be rather heavy." After explaining the principles of mechanical heating, he concluded by saying that what he wanted to make out was that the matter had been fully considered by the committee, the Board, and professors on ventilation and electric lighting, and whether they could get a better elucidation of the matter at a general meeting attended by a good many people who did not know where the buildings were, what they were there for, or what required to be done, would be brought out before the meeting ended. Mr. Knight Forbes, convener of the Building Committee, having read the report of the Drapery and Buildings Joint Committee on the suggested alterations and improvements, the chairman read the report of the Buildings Committee on the question of the introduction of electric lighting, which bore that Prof. Kennedy, of London, estimated the cost of all the apparatus necessary for supplying 300 8-c.p. electric lamps, exclusive of wiring, at £625. In calculating the expenses of production, he allows 5 per cent. for interest, 5 per cent. for depreciation, £70 per annum for a mechanic, £32 for coal, £10 for oil, waste, and stores, and £30 for renewals and maintenance, altogether, £202. If to the above be added the cost of wiring which, according to the estimate of Messrs. Holmes and Co., Newcastle, would be £625, and allowing 5 per cent. for interest, and 5 per cent. for depreciation—the cost of production would be £264 or thereby per annum. The committee learned that the gas bill for the past 12 months was £204, and if the additional gas required at the new premises facing Gallowgate were added, which they estimated will amount to £92 (making altogether a gas bill for the central premises of £296), there would be a saving in favour of electric light of £32. Mr. Hunter, engineer (one of the directors), said that the Scottish Wholesale Society had introduced an installation of over 2,000 lights. If that society had seen their way to adopt electricity when gas was cheaper in Glasgow than in Aberdeen, he did not see why the Northern Co-operative Company should not do the same. Mr. William Milne, Victoria street, strongly opposed the introduction of electric lighting. Treasurer Bisset said that although every private individual could not manufacture electric light so cheaply as he could get it from the city, if the Co-operative Company took it in conjunction with their ventilation scheme, he was satisfied that they could manufacture a light better suited for their purpose than the gas they were at present supplied with. After some further discussion the meeting terminated.

Portsmouth.—At the Portsmouth Town Council last week, the Electric Lighting Committee submitted the tenders received for the electric lighting mains and the various fittings and accessories. Eight tenders in all had been received in time, and of these five provided for armoured cables for the high-tension mains and arc light conductors being laid direct in the ground, and a drawing-in system for the low tension mains, while the other three provided a drawing-in system for all the mains. The five tenders providing for armoured cables gave the following fixed prices: British Insulated Wire Company, £10,344; Silvertown Company, £10,385; Callender Company, £10,639; Siemens Bros. and Co., £10,706; W. T. Henley's Telegraph Works Company, £10,907. The three tenders providing for a drawing-in system were: International Electric Subway Company, £10,504; W. T. Glover and Co., £12,465. 7s. 8d.; Reid Bros., £12,498. Adding to these several sums the estimated cost of the fittings and accessories according to the schedule of prices in each tender, the amounts were as follows: On the first five tenders: British Insulated Wire Company, £11,673. 10s.; Callender Company, £12,537; Silvertown Company, £12,712; Siemens Bros., £13,407; W. T. Henley's Company, £14,579. On the other three tenders: International Electric Subway Company, £12,043; W. T. Glover and Co., £15,221. 7s. 8d.; Reid Bros., £15,244. After consideration the committee came to the conclusion that, looking at the small difference in cost, it would be better to provide for a drawing-in system for all the mains, as with this system it would scarcely ever be necessary to reopen the roads or footways after the cables had been once laid, and the committee therefore recommended that the tender of the International Electric Subway Company be accepted at the fixed price, and that the committee be authorised to order the fittings and accessories under the contract at their schedule of prices. Under the contract with Messrs. Yates and Thom, and S. Z. de Ferranti, Limited, there was a schedule of prices for transformers and other fittings, and the committee recommended that they be authorised to give orders under this schedule to the extent of £3,000. The committee recommended that a certificate from the engineers for £500 in favour of Mr. T. W. Quick in respect to the electric light station be paid; and also that the common seal be affixed to the contracts with Messrs. Yates and Thom, and S. Z. de Ferranti, Limited, and Messrs. C. A. Parsons and Co. for the supply of electrical plant. Alderman Ellis, in moving the adoption of the first clause, announced that the International Electric Subway Company's tender had been altered to £12,000, and their tender, including all accessories, from £12,043 to £13,539. That day the committee had arrived at the last contract for completing the installation entrusted to their care, and notwithstanding the fact that they had procured the best possible machinery of the most improved make, and including the cost of the mains, the total amount would be considerably less than the estimated sum. Mr. Ross seconded. Mr. Light thought that as the first tender of the International Company was wrong, it should be thrown out. Alderman Scott Foster said that the committee were satisfied that the mistake was *bonâ fide*, a lump sum of £3,000 for excavations having been inadvertently omitted. He dwelt upon the superiority of the subway system over that of iron pipes, and while admitting that it was inconvenient to have to amend a tender, pointed out that under existing circumstances it would be advantageous to the Council to act in accordance with the proposal of the chairman of the committee. Ultimately the report was agreed to.

St. Albans.—At the meeting of the St. Albans City Council, Mr. Toulmin moved "That it is expedient that the city be lighted by electricity, and that a committee be appointed to consider and report what steps should be taken for carrying out the work." In bringing the resolution before the Corporation, Councillor Toulmin said that by the courtesy of Mr. Longmore, the town clerk of Hertford, he had been supplied with an excellent report of a committee which had been appointed by the Corporation there to consider this matter. A capable engineer had been consulted by that committee, and they reported that they were thoroughly convinced of the advantages of electrical energy for lighting purposes, and they had no hesitation in recommending the Corporation to embark upon this undertaking—that of supplying electric light to the town—as they felt sure it would prove to be a paying concern, and a source of considerable income to the borough. They also reminded the Corporation that electric lighting was no longer in its infancy, but it had been tried and found successful in many places. Continuing his remarks, Councillor Toulmin said that, looking at the estimate of the cost of lighting the streets this year, he found it was £940, and that seemed to him to be a considerable sum. He believed that if they went systematically to work, and picked the brains of other authorities and profited by the experience of other towns, they would be able to carry this out in such a way as to reflect considerable credit on the town and materially benefit the residents. It was well worth making an effort to obtain the advantages which resulted from an installation of the electric light. There were many facts and figures which he was prepared to bring before the Council, but he would not trouble them that evening. He proposed, therefore, that the Mayor, Alderman Miskin, Councillors Rowden, Bennett, Hurlock, Hitchcock, and Gibson be appointed a committee to consider and report on the subject. Mr. H. P. Smith seconded. Mr. Barnard objected to such an important subject being brought forward, as this had been, at a monthly meeting, without having previously been considered in committee. His opinion was that this subject should first have been brought before the Urban Sanitary Committee. He proposed as an amendment that this matter should be referred to that committee. He thought that they should proceed very carefully, particularly when it was remembered how great a failure had been the attempt to light Barnet by electricity. Mr. Hurlock thought the work ought to be done by a private company. Mr. Smith said he quite agreed that the time had not arrived for St. Albans to be lighted by electricity, but he did take strong exception to the statement that it should be left to a private company to step in and supply electric light to the city. When electric light came down to the price of gas, the Council would be bound to take it up. He wished that former corporations had been more enterprising, as if they had been the water supply and gasworks would be in the hands of the Corporation, and the profits arising from them would have paid half the rates. They must see that when the time arrived a private company did not step in, and the profits, as in the case of the waterworks, go to those who resided outside the city. The waterworks and gasworks ought to belong to the ratepayers, who should profit by the receipts. He was certainly in favour of a committee being appointed, as proposed by Councillor Toulmin, to enquire and not to act, because if were proposed to do anything definite beyond obtaining information, he should not have agreed to the appointment of the committee. After further discussion, the resolution

was carried in an amended form, and the Council then went into committee.

Torquay. —Mr. W. H. Trentham, electrical engineer, of Bristol, has been engaged by the Torquay Town Council to inspect the town and report on the ways and means of lighting it by electricity. In his report to the Council he advises the adoption of the Bath Saloons as the site of the central station. There no expense would be necessary for buildings, saving the town £3,000 or £200 a year. To avoid the smoke nuisance he suggests that gas should be used, or that the boilers should be fired by gas generated in a regenerative furnace. After careful enquiries, Mr. Trentham has come to the conclusion that 1,500 lamps of 16 c.p. would be taken up immediately the current was available. This estimate is independent of the hotels, which he thinks would certainly require not less than another 1,000 16 c.p. lamps. His advice is that provision in the first instance should be made for 3,000 lamps of the power indicated. These would require about 420 i.h.p., which might be advantageously divided between three engines, each indicating 120 h.p., and one small engine of 60 h.p. Owing to the length of the streets (5,500 yards), a low pressure system would be unsuitable. He estimated that high pressure mains, including low pressure connecting mains between the transformers, would cost about £5,000, while the cost of low pressure network and feeders, allowing the usual losses, would be about £15,000. If the Bath Saloon site was adopted as the central site, he recommends the employment of steam engines for the heavy work between dusk and 10 p.m., and a 60 h.p. gas engine for the remainder of 24 hours. The approximate cost of steam plant, with gas engine for day lighting, would be £17,403; and of maintenance £3,100. While making provision for street lighting, Mr. Trentham says there could be no object in altering the present mode of illumination generally. He proposes that 16 arc lamps be provided, one being at the top of Lower Union street, another outside the Town Hall, one at the corner of Abbey place and Fleet street, two at Ellacombe Green and Market Corner respectively, five in new Pleasure Gardens, and the remainder distributed between Beacon Hill, Victoria parade, Torwood street, and the Strand. These lamps would cost £20 each, or £320 per annum, and would displace about £45 gas lamps costing about £225 a year, and giving some 1,130 c.p. against 11,000 c.p. given by the arc lamps. The revenue per annum, taking the current at 6d. per unit, and including £320 for the arc lamps, would be about £3,320; at 7d., £3,829; at 8d., £4,320, not allowing for any revenue from meters and motors, cooking apparatus, etc. The electric current at 6d. per unit is approximately at the same rate as gas at 4s. 5d. per 1,000ft.; but in practice it is found so easy to economise the light by at once turning it out when not required, that the price in actual use is practically equal to gas at 3s. per 1,000ft. Mr. Trentham suggests, however, that the price be fixed at first at 7d. per unit (equal to 3s. 6d. per 1,000 for gas), and that discounts be allowed according to the number of hours the light has been in use. He adds to his report: "It is probably hardly necessary for me to urge strongly the advisability of the Council carrying out this work and retaining their powers in the face of the monopoly enjoyed by gas companies. Electric lighting will pay its way from the commencement, and afterwards prove a very important source of revenue." He advises the Council to on no account transfer their provisional order, whether it is decided to carry out the installation at once or not.

Aberdeen.—Very satisfactory progress is being made with the preliminary work in connection with the electric lighting, says the Aberdeen paper. Some little time ago we chronicled the commencement of operations for the erection of the generating station in Cotton street, whence the supply of electricity will be distributed over the city. At present the walls of the buildings are 4ft. or 5ft. above ground; with dry, open weather rapid progress with the work may be expected. While this has been going on in connection with the buildings, a commencement has also been made with the laying of the copper mains for conveying the electricity through the streets. The pavement has been opened from the station in Cotton street along Castle terrace, and the mains—enclosed in a watertight concrete culvert—have been laid half way along the terrace. So far, attention has been directed to the laying of mains for the supply of the incandescent light only for private lighting; at a meeting of the Gas Committee of the Town Council, a proposal was brought forward with reference to the supply of electricity for the arc light in view of the lighting of the streets also. Treasurer Bisset suggested that advantage might be taken of the opening of the pavements to lay a pipe with a cable in view of the lighting of the streets by the arc system. The suggestion was generally approved by the committee, and it was resolved to approach the Council on an early date for authority to proceed with the work. Should the desired authority be given, Prof. Kennedy will, in all probability, again visit Aberdeen and report upon the scheme. As indicated, the scheme which is at present in progress is for private lighting alone—that is, for the supply of light and power, if required, to houses, shops, etc., along the line of the mains, in the same way that gas is now supplied. The area through which mains are to be laid at present is the central part of the city, comprising Castle and Union streets, Union terrace, the Viaduct, School hill, St. Nicholas street, Broad street, Market street, and part of the quay. At some future date the mains will be extended to the western part of the city. The system is a low tension one and the current is carried, whenever possible, by bare copper strips laid on porcelain insulators set in a concrete trough or culvert. The culvert will in all cases be under the pavement; where it is necessary to go into the road, and at all street crossings, insulated cable is to be used, drawn into cast-iron pipes. Brick inspection boxes will be built in the pavement to enable all joints to be made and inspected, and to take off the services to the houses. The boxes will be closed by a cast-iron top, faced with cement. The generating station in Cotton street forms part of the gasworks. The engine and boiler rooms are on the ground level, and the battery-room is above the engine-room. In the boiler-room are to be four boilers arranged to burn gas coke. In the engine-room are five high speed steam engines, three of 80 h.p. each, and two of 40 h.p., each driving a dynamo direct, without ropes or belts. The switchboard, by which the regulation and distribution of the current are carried out, is in the engine-room, and is arranged so that the engineer in charge has full control of the system. The engine-room is large enough to admit of a large increase of the supply over that now contemplated, and the arrangement of pipes and machinery is such that the chance of any stoppage of the supply by breakdown is reduced to a minimum. The buildings for the station have been designed by Mr. Alexander Smith, the superintendent of the gas department. The Electric Construction Corporation of Wolverhampton are the contractors for the machinery in the station, Messrs. Siemens Bros. for the switchboard, and Messrs. Scott and Sellar, of Aberdeen, are now carrying out the work of laying the main.

The Blackpool Tramway.—In the minutes of the Blackpool Electric Lighting Committee of June 23 was a resolution to the effect that Mr. John Hesketh, borough electrical engineer, be relieved from the traffic management of the tramways; that Mr. John Lancaster be appointed traffic manager; and that Mr. Hesketh be desired to retain the control of the electric arrangements connected with the tramways, and of the book-keeping as at present outside the treasurer's department. At the Town Council meeting when this was discussed, Mr. Bibby said he should like to know if Mr. Hesketh was going to retain the £50 which had been paid to him for the management of the tramway. He moved that the resolution be referred back for further consideration. Mr. Pearson said the committee had gone into the whole of the circumstances connected with the alteration proposed. It was a very delicate point to raise in Council. Mr. Hesketh had had control of the electrical arrangements, and had also acted as traffic manager. There was no alteration proposed except that Mr. Lancaster should be made responsible for the conduct of the traffic, thereby relieving Mr. Hesketh. The Council voted him £50 for doing the work temporarily. Mr. Bibby said if Mr. Lancaster had the additional responsibility he ought to have a certain proportion of the payment. Mr. Mather agreed. Mr. Parkinson, in rectifying one or two mis-statements which had, he believed, been made through ignorance, remarked that at present it was impossible for any man to work the trams satisfactorily. If they thought £50 more than paid for the work Mr. Hesketh did they did not know the value of labour. He anticipated that a division of the work would cause confusion. They had better maintain the present system until the summer was over and then spend £4,000 or £5,000 on a system which could be used satisfactorily. If they did not give full facilities for carrying out work, they could blame nobody. Mr. Councillor Pearson considered that Mr. Hesketh's duties had multiplied so as to make it absolutely necessary to relieve him from the management. The receipts showed a net increase of something like £400 up to the last meeting upon the previous year's work, but as no alteration in the system could be made before the end of the season complaints would be general for some time to come. In reference to the above it is interesting to give the original discussion on this appointment in December, 1892. Extract from the electric lighting and tramway minutes: "'That a sum of £50 be allowed to Mr. Hesketh, as the general manager of the Blackpool tramways for the period from the 9th of September, 1892, to the 9th of September, 1893.' Mr. Councillor Bickerstaffe called attention to the sum of £50 recommended to be given to Mr. John Hesketh for managing the electric tramways. In his opinion something ought to be shown as to the result of the working of the trams before they started to increase salaries. The Mayor said that Mr. Hesketh was asked to take over the management of the trams but although it was not provided at the time that he should have any remuneration, it was thought that he should be paid extra. The payment of £50 was for his services as manager of the tramways for one year, to date from September last. He thought that this was little enough payment for the extra work Mr. Hesketh had done. Mr. Alderman Bickerstaffe said that subsequent to the appointment of Mr. Hesketh as electrical engineer, the Corporation bought the tramways and required a general manager. They considered that they could not have a better man than Mr. Hesketh, and they therefore appointed him their general manager. When he told them that the general manager of the old company received £150 per year, and when they considered that Mr. Hesketh had only £50 per year for the same duties, surely they would not say that the Corporation was paying too much for the work. This was not an increase of salary, but merely payment for extra work outside his duties as electrical engineer, etc."

Richmond (Surrey).—The following report was presented to the Richmond Town Council meeting by the Electric Lighting Committee: "Mr. Shoolbred's account has been thoroughly gone into by the committee, with the result that the town clerk has been instructed to write Mr. Shoolbred to say that after having carefully examined his account and the resolution relating to his appointment, they are prepared to recommend the Council to pay him the sum of 100 guineas, the committee being of opinion that this sum is fully equal to what he would be entitled to receive under the arrangement come to. The committee further report

that the chairman and town clerk had an interview with Prof Kennedy, and suggested his accepting the appointment of consulting engineer to the Council should the appointment be offered to him by the Council. He, however, expressed his regret at being unable by reason of his other engagements to undertake further duties The committee have since been in communication with Messrs Urquhart and Small, electrical engineers, of Victoria street, Westminster, and have had an interview with Mr. Small, of that firm, who is a resident in Richmond, and having regard to the fact that they have carried out considerable works under Prof Kennedy at Dundee, the committee beg to report that Messrs Urquhart and Small have offered to undertake the duties of electrical engineers to the Corporation by letter dated June 30, on the following terms: 'We undertake to examine all the plans and drawings submitted to the Corporation for approval by the electric lighting contractors, and to advise the Corporation on such plans, and, when required, to prepare and submit revised plans We undertake to superintend the laying of the mains and the construction of the junction and other street boxes, on behalf of the Corporation, so as to ensure that this work is carried out in a substantial and lasting manner. We undertake to examine and test the works executed, and the plant erected by the contractors, when completed, and to report to the Corporation on the same. We undertake to attend to and advise the Corporation with reference to the serving of all statutory notices relating to the Richmond provisional electric lighting order, to report to the Corporation from time to time, and to attend the meetings of the Electric Lighting Committee of the Corporation when required Our fee for the above work, from the date of our appointment up to the date of handing in our report on the works when completed, will be one hundred guineas, which will include all travelling and incidental expenses.' The committee recommend the appointment of Messrs Urquhart and Small as electrical engineers to the Corporation on the above terms." Upon the motion of Councillor Heasler it was resolved that the recommendation of a former report not yet dealt with, that Mr. Shoolbred's resignation should be accepted, was agreed to. Councillor Heasler said that he would not go into the question of Mr. Shoolbred's accounts on that occasion, but he moved the recommendation as to the appointment of Messrs. Urquhart and Small, which he thought was a very satisfactory one. This was agreed to. Councillor Heasler said that the works were now progressing more satisfactorily. The clerk read two letters relative to the sudden disappearance of the electric light during the progress of the last meeting, the first from Mr A. M. Smyth, resident engineer, Richmond electric light station: "Having reported to Messrs Latimer Clark, Muirhead, and Co. that the lights in the Town Hall went out on Tuesday, the 4th, about 9.30 p.m., I have been requested to draw your attention to the cause, which was due to the burning out of the main fuse situated in a locked cellar in the building. This fuse was not put in by us, as our own responsibility ceases at the terminals which connect our mains to the building" The second, from the contractors, Messrs. Strode and Co., explained that the fuses they had put in were capable of carrying 200 amperes at 100 volts, and they think there is no doubt that the reason they suddenly fused must have been owing to an increased pressure on the company's side, as none of the section fuses went throughout the building which protect the small circuit, but only the main fuses Councillor Dimbleby suggested that the letters should be referred to the Works Committee to see if there was anything wrong with the installation. Alderman Robinson thought it would be better for the matter to go to the Electric Lighting Committee. Councillor Dimbleby's proposition was accepted.

PROVISIONAL PATENTS, 1893.

JULY 3.

12971. **Improvements in alternating-current motors.** Olof Dahl and Simeon Lee Phillips, 34, Southampton buildings, Chancery lane, London. (Date applied for under Patents, etc., Act, 1883, Sec. 103, 8th December, 1892, being date of application in United States.) (Complete specification.)

12981. **Improvements in signal, telegraph, or other posts.** Illius Augustus Timmis, 2, Great George-street, Westminster, London.

JULY 4.

13024. **Improvements in instruments for measuring and indicating electrical energy, and for other measurements.** George Cheffey James, Bank buildings, George street, Sheffield.

13064. **Improvements in devices for prevention of retardation in electric cables.** Silvanus Philips Thompson, 323, High Holborn, London.

13066. **Improvements in or relating to the manufacture of incandescent mantles or filaments for use in connection with gas or electric incandescent lamps** Alfred Julius Boult, 323, High Holborn, London (Otto Hermann Steuer, Germany.) (Complete specification.)

13081. **Improvements in the construction of plates for secondary batteries.** James Pitkin, 6, Bream's buildings, Chancery-lane, London.

JULY 5.

13111. **Improved traverse motion of the commutator and armatures of dynamos and electric motors.** John Pease, Valley Mills, Apperley Bridge, Yorkshire.

13101. **Improvements in the method of winding for dynamo-motors for balancing a three-wire system of electrical distribution.** David Urquhart, 17, Victoria street, Westminster, London

13133. **An improved automatic electromagnet switch.** James Hardie McLean, 20, High Holborn, London.

JULY 6

13203 **Improvements in electric traction and apparatus therefor** David Cook, 28, Southampton buildings, Chancery lane, London.

13217. **Improvements in secondary electric batteries** The Lithanode and General Electric Company, Limited, and Job Thomas Niblett, 47, Lincoln's inn fields, London.

13218. **Improvements in plates or elements for secondary electric batteries.** The Lithanode and General Electric Company, Limited, and Job Thomas Niblett, 47, Lincoln's-inn fields, London.

JULY 7.

13263 **Electric apparatus for operating dental implements.** Charles Arthur Allison, 52, Chancery lane, London. (Oscar Henry Pieper and John Henry Harbour, United States

13274. **Improvements in the manufacture of plates for electric accumulators.** Constant Rousseau, 4, South street, Finsbury, London

13276. **Improvements in and relating to electric arc lamps.** Edmund Jokl and Carl Holzapfel, 45, Southampton buildings, Chancery lane, London.

13279 **Improvements in ear-pieces for telephones** Rudolf Seiffert, 45, Southampton buildings, Chancery-lane, London. (Complete specification.)

JULY 8.

13336. **Improvements in the electrolytical production of nickel and other metals.** Carl Hoepfner, 45, Southampton-buildings, Chancery lane, London

13339. **An improved manufacture of carbon for electrical purposes** Henry Harris Lake, 45 Southampton buildings, Chancery lane, London (Adam Charles Girard and Ernest Auguste Georges Street, France.)

13340. **Improvements in and relating to electric furnaces** Henry Harris Lake, 45 Southampton buildings, Chancery-lane, London (Adam Charles Girard and Ernest Auguste Georges Street, France.

13341. **Improvements in transforming electrical energy of high tension into low tension and in apparatus therefor** Reginn Niewerth, 1, Quality court, Chancery lane, London.

SPECIFICATIONS PUBLISHED

1892.

9108. **Electric batteries.** Shrewsbury and Dobell
10999 **Electric clocks** Webber.
11194 **High-tension circuits.** Drake and Gorham.
11822 **Driving clocks, etc., electrically.** Aron.
13381. **Electrical storage plates.** Bright and Mercier.
14160. **Electrically working the gear of guns** Grimston
14250. **Secondary batteries.** Rosenthal and Doubleday.
14674. **Electric telephonic apparatus.** Marr.
16545. **Galvanic batteries.** Ball.

1893.

4368. **Electric arc lamps.** Ward.
6559. **Electric heating apparatus.** Dewey.
6885 **Electric railways.** Lake. (Cattori)
7389 **Electrically welding metals.** Thompson. (Coffin.)
8808. **Electric accumulators.** Lehmann.
9552 **Microphones and telephones.** Paetzold.
9818 **Electrical conductors.** Cummings.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3½
— Pref.	—	2½
City of London	—	11½
— Pref.	—	12½
Electric Construction	10	4
Gatti's	—	5¼
House-to-House	5	5½
India Rubber, Gutta Percha & Telegraph Co.	10	23
Liverpool Electric Supply	5	6¼
	[illegible]	4½
London Electric Supply	5	1
Metropolitan Electric Supply	—	6¾
National Telephone	5	5¼
St. James'	—	8¼
Swan United	3¾	3¼
Westminster Electric	—	5¾

NOTES.

Historical Collection Lost.—The ship containing Prof. Ferraris's collection of apparatus *en route* for Chicago, was sunk in the harbour of Genoa.

Manchester.—The important event of turning on the electric light from the Corporation mains to the city of Manchester took place informally last week.

Gilgit Telegraph.—Satisfactory reports have reached Simla of the progress made in laying the new telegraph from Srinagar to Gilgit. The line is being rapidly carried forward.

Fire at Manchester.—It is stated that the fire at the Manchester Reference Library, which caused damage to 10,000 volumes, resulted from the careless use of candles in the dome by the men who were fitting electric light wires.

Coast Communication.—The second congress of the International Maritime Congress was opened on Tuesday at the Institution of Civil Engineers. A discussion was held on "Communication between Lightships and the Shore."

Accumulator Literature. — A corrected list of articles giving the description of all types of accumulators, is given in the *Electrical World* of July 1. It contains exact references to several hundred articles in the electro-technical papers.

Death of an Electrician.—The death is announced of M. Marie Davy, the electrician and astronomer. He died on Sunday at Clamecy, Nièvre, at the age of 77. He is best remembered in the electrical world by the cell which bears his name.

Lightning among Telephones.—A considerable proportion of the telephone trunk line between Cupar and St. Andrews was destroyed by the lightning on Sunday, and some of the instruments in the St. Andrews exchange were rendered useless.

Watertight Doors.—The suggestion is made that in case of sudden disaster, such as that which overtook the "Victoria," an arrangement for the simultaneous closing of watertight doors controlled electrically from the deck, would prove most useful.

French Engineers at Chicago.—The Municipal Council of Paris has voted 3,000f. for the chief engineer of lighting and highways to visit Chicago and report upon the exhibition in general, and America in particular, as to lighting and electric traction.

Attraction of Vacuum Tubes. — Sir David Salomons has found that vacuum tubes when lighted have a greater attraction together than is accounted for by the current passing or the static effect. A spiral tube sucks like a solenoid: no repulsion takes place.

Heilmann Locomotive.—In a trial at Havre with the Heilmann locomotive, with the motors connected to a temporary axle, it was found that under proper test conditions a rotation equivalent to 120 kilometres per hour could be obtained, and without noticeable vibration.

Night Photography.—Mr. Mitchell, an enterprising photographer at Blackpool, has taken a photograph at Blackpool—when the tower was illuminated for the Royal wedding—at night, the plate being exposed for an hour and 10 minutes. The tower is well defined, and the electric light came out a mass of white. As a specimen of night photography the plate is very interesting.

Telegraphy on the Paris Telephone Line.—Some experiments have been made during the last month on the Paris-London telephone line to ascertain the practicability of telegraphing along the line without interfering with its telephonic properties. Several methods have been tried, some with good result. It is expected a trial in practice will be made on one of the wires.

Incandescent Lamp Manufacture.—The transformation of silk or cotton thread into carbon filament for lamps is carried out usually in two processes—the parchmentisation of the thread and the carbonisation in a mould. Mr. Pope simplifies the operation by covering the thread with a coating of paraffin, by immersion in a bath of this hydrocarbon under considerable pressure. When the paraffin has penetrated thoroughly, the filament is at once carbonised.

Battery Traction.—The *Mechanical World* this present week contains a letter from Mr. Epstein on accumulator traction, emphasising the fact that his batteries have run 6,000 miles at Birmingham without renewals. Maintenance at 1½d. per mile means £37 earned, and the cost of renewals as known to the company is £19, leaving ¾d. per car mile profit. It is objected, however, that Mr. Carruthers-Wain has not yet vouched for the financial success of the running of battery cars at Birmingham.

Trolley Patents.—Considerable attention is being at last given in America to Benson Bidwell, one of the earliest workers in electric traction. Mr. Bidwell ran his electric car in Philadelphia and Boston in 1884 and 1885, and patents were issued to him in 1885 and 1887 for the under-contact pivot-jointed trolley, which is now universally used. Suits have been entered to test the legality of the Bidwell patents, which, if upheld, will control as important interests as the incandescent lamp patents.

Apartment Houses.—The first of the great "apartment houses" in New York was that erected by Mr. Rutherford Stuyvesant, near Third - avenue, in 1870. Mr. Everett Blanke, in an article entitled "The Cliff-Dwellers of New York," in the *Cosmopolitan*, estimates the present number of these immense buildings in that city at 700. Nearly all are provided with electrical and steam appliances, requiring the outlay of so much capital and attention as are rarely found even in the private dwellings of American millionaires.

Patin Flywheel Dynamos.—M. F. Desquiens, in the *Génie Civil*, describes the new types of machines recently brought out by M. Patin. These are alternate-current dynamos attached as flywheels to an horizontal engine, making a sound engineering job. Alternate-current motors are also made by M. Patin, whose researches, in conjunction with M. Levavasseur, have solved, it is stated, the problem of alternate-current transmission. The Patin alternate-current motors are adapted for either high or low pressure, and are made for high or low speeds.

Telephony.—We are informed that, with the assistance of Mr. Arthur J. Stubbs, Mr. W. H. Preece, F.R.S., has just finished the preparation of "A Manual of Telephony," which will be published early next month by Messrs Whittaker and Co. The authors have unusual opportunities for obtaining accurate information on technical details connected with their subject, and the 500 pages of the new book will doubtless be a veritable mine of information for all who are interested in telephonic matters. An important feature in the work is the large number of specially drawn diagrams.

Inventions Wanted.—The dynamo is nearly perfect. It returns 95 or 96 per cent., but even it might do without

a commutator, or do with a simpler one. The whole dynamo requires "mechanicalising," so to speak, still more. One well-known mechanical engineer once expressed himself in a dynamo-room: "I never see a dynamo armature but I think of a bundle of wires as a stick." But if the dynamo were perfect, there are other worlds to conquer. The incandescent light uses about ½ per cent. of the energy of the coal usefully. How can we save the other 99 per cent.? Here is the one great question still before electrical engineers.

Books Received.—We have received "Captain Enderis—First West African Regiment," a novel by Archer P. Crouch, author of "On the Surf-Bound Coast," etc.; two volumes; published by Messrs. W. H. Allen and Co.; 21s. We have before us also a second edition, revised, with large additions, of "Electric Light Fittings—a Handbook for Working Electrical Engineers," by John W. Urquhart (Crosby Lockwood and Co.). Chapters on street cable work, specifications, fire risks are added, and the lighting of ships is extended by a description of the installation on the "City of New York," Inman liner, by Mr. Chas. H. Peters, electrician on that vessel.

Edinburgh Royal Society.—At the last ordinary meeting of the Royal Society of Edinburgh for the present session, held last Monday, Prof. Sir Douglas Maclagan, M.D., president, in the chair, Prof. C. G. Knott explained a method of estimating magnetic induction in iron. He said that however it might vary, it appeared that whether in the case of a solid bar or a tube the total induction was exactly the same in small fields, consequently he inferred that induction was largely a superficial phenomenon in low fields. But as the field was made stronger induction became less and less superficial, and passed, as it were, into the tube. Prof. Tait, on behalf of Mr. G. Romanes, explained a method of attraction by graphic process.

Metric System.—"Engineers here," says an English engineer in Brazil, "will not take the trouble to convert our hodge-podge mixture of weights and measures into the metrical system. They do not understand them, and have no basis of comparison with Belgian and French goods. Brazilians like English goods: believe them best and cheapest in the long run, but find it impossible to estimate from your measures." English engineers must submit to use the metric system, at any rate for countries speaking the Latin tongues—this becomes more and more evident every year. The Sheffield trades use one or the other indiscriminately, and the steel-rolling lists are always made on the two systems of measure. Why cannot electrical engineers do likewise at once?

The Poor Man's Power.—Mr. Preece has given it as his opinion that electricity will eventually provide the poor man's light. The electric motor is destined to be the poor mechanic's friend. Its management and control is simple, its service is in direct and immediate command, it requires no licensed engineer or fuel, and in economy of space occupied has no competitor. In some instances where needed for intermittent use, power can be furnished at one-tenth to one-fifth of the cost of steam. The electric motor (says the *Age of Steel*) "has found its way into plumbing, metal spinning and machine shops in New York, and as an economic factor, with the other advantages named, there can be no grave question as to its more general adoption. We predict the renting of electric power to yet become a remunerative and general enterprise."

South Staffordshire Tramways.—During the meeting of the Municipal Engineers last week at West Bromwich, a visit was paid to the generating station of the electrical section of this tramway system. The tramway company had placed at the disposal of the institute steam trams from the Town Hall, West Bromwich, to the commencement of the electrical section, whence the trip to the generating station was made on the electric cars. Mr. A. Dickenson, C.E., J.P., met the members at the station and explained the apparatus. His paper read before the Tramways Institute on December 30, 1892 (reported in the *Electrical Engineer* of January 6, 1893), was distributed to the members. An illustrated description of the system will be found in our issues of November 11 and 18 of last year. So far as we could judge or hear of the running of the cars, the work is carried on in an excellent manner.

Junior Engineering Society.—Recent visits of this society have been to the Deptford station of the London Electric Supply Corporation and to the Blackwall Tunnel works, both occasions being largely attended. At Deptford the members were shown over by Mr. Brown, who fully explained the arrangement and working of the plant and pointed out the numerous features of interest. On behalf of the contractors, Messrs. Pearson and Sons, the party were received at Blackwall by Mr. E. H. Tabor and Mr. L'Estrange, under whose guidance the works on the north side were first inspected. The members then proceeded across the river to Greenwich, and after being shown the work at surface, descended one of the caissons and passed to the working face where the cutting shield was seen in operation driving the tunnel. At the conclusion of the visits the thanks of the members for the attention received were expressed by the chairman, Mr. Sidney Boulding, M.I.M.E.

Polyphase Currents in Spain.—The two neighbouring towns of Elgoibar and Eibar, in Spain, will shortly have installations of polyphase-current plant for light and power. The work is being carried out by Messrs. Siemens and Halske, using the power of the River Deva, which, with about 30ft. fall, gives 300 available horse-power. Hercules turbines are used at 200 revolutions, driving a 80-kilowatt "Drehstrom" dynamo. The current generated at 120 volts will be transformed up to 5,000 volts, and conducted by overhead wires on oil insulators to the two towns situated one and three miles distant respectively. About 60 incandescent lamps will be used in the street-lighting in Elgoibar, and several hundred private lights. In Eibar, an industrial town, 120 lamps will be required for street-lighting, and 400 lamps for private lighting are ordered. Electromotors of from 1 h.p. to 25 h.p. will be installed for transmission of power. Don Ermanno Schilling is the Madrid agent who has carried out the details of this installation.

Physiological Effects.—According to Dr. Stéphane Leduc, professor at the School of Medicine at Nantes, the alternate currents obtained with electrostatic machines have physiological properties very different to those attributed hitherto to currents of high pressure and great frequency. If the ball terminals of the conductors are grasped in the hands, nothing is felt if the exciters give a continuous series of sparks; but if the current is localised on the skin by means of a blunt point, as soon as the point passes over a sensor or motor nerve the nerve is excited in all its distribution below the electrode; the impression provoked in the sensor nerves enables the limitation of their distribution to be exactly mapped out, and the least displacement of the electrode on the surface of the skin immediately causes all sensation to cease. These currents, therefore, enable the nervous excitation to be localised much more accurately than has been possible hitherto, and this property makes it likely that such currents will prove useful to physiologists.

The Lenzie Merchant and the Telephone.—"One good merchant in Lenzie," says an amusing account in the *Glasgow News*, "has been astonished by his telephone. A few days ago he heard a loud report, proceeding, apparently, from one of his shelves, on which were stacked a number of whisky bottles wrapped in the customary tissue paper. He then saw these filmy envelopes burst into flame, and the woodwork had begun to singe before he could get the flames extinguished. On examination, he found that the telephone wire, which was conducted behind the shelving, was severed, and that each end was fused. As this happened while a heavy thunderstorm was being experienced at a little distance off, the conclusion arrived at is that the wire had been struck by lightning, and that the current, being too strong for the wire to conduct, had 'bust' things in general—that is not scientific, but it is near enough. The instruments and wire have been put to rights now. But ever since, when that merchant has had occasion to handle the receiver he caresses it with all the bashful timidity of the kiss of sweet seventeen." The incident, it must be admitted, is very well described.

Postal Telegraphs Illuminations.—Want of space in our last issue compelled us to hold over reference to this matter. Amongst the many beautiful illumination effects that were to be seen in the streets of London on the evening of the Royal wedding day, July 6, that exhibited on the huge building of the Postal Telegraphs merits notice. Starting at the corner facing the top of Cheapside, two horizontal lines of lights travelled along the building, illuminating the whole length of that side forming part of Newgate-street and half-way along the frontage of the building. The lower line was positioned on a level with the first floor, and the other marked out the top of the building. At the Cheapside corner was a design consisting of the letter "M" placed within the letter "G," whilst two sheafs sprung up from below, encircling the monogram. Over the portico, in the front part of the building, was placed a crown having the letter "V" on the left and the letter "R" on the right. The entire designs were made by incandescent lamps of 16 c.p., and altogether about 1,300 electric lamps were used, which were run off the dynamos that supply the electric light to the General Post Office. The illuminations were on Friday and Saturday evenings following, and caused admiring crowds to assemble near the General Post Office buildings. The work was only commenced late on Monday afternoon and the whole was ready by Thursday afternoon, a very small staff of men being at it—a smart piece of work for such a short time. We understand that the entire expense has been met by private disbursements on the part of those interested. We must compliment Mr. Probert, the superintendent of the electric light department, on the unqualified success attained, and the expeditious manner in which the work was accomplished.

Technical Education.—In view of the importance of the subject of electrical engineering and of the large increase in the number of students in section, the governors of the Merchant Venturers' School at Bristol have decided to materially improve the equipment of this department. For this purpose a complete installation will be provided. It includes two small dynamos of different types, built by the students of the school, and a large four-pole experimental dynamo, specially built by the Brush Electrical Engineering Company. The latter has its field-magnet coils so wound that it can be used as a series, shunt, or compound wound machine; it is also provided with a special exploring coil in the armature, so that magnetisation of the armature can be examined, and the machine is so constructed that an alternating current of slow periodicity can be obtained. These three dynamos will be driven by a horizontal gas-engine, and will be used for experimental purposes, and also for charging a set of electric power storage batteries placed in the electrical laboratory; from these cells currents will be conveyed to the lecture theatre and to the laboratory tables. During the past few weeks the senior students in the electrical engineering section of the school have been busily engaged in placing the necessary cables and wires throughout the building, and the whole will be in readiness for use during the ensuing winter session. The senior students will in turn be placed in charge of the installation, and will thus have ample opportunities of becoming acquainted with the practical methods of treating dynamos and electric light plant. Considerable additions are also being made to the electrical measuring instruments of the school, and it is proposed to utilise the town electrical supply for experiments with alternating currents, as well as for lighting a part of the building. The remainder of the school premises will be gradually wired by the students.

Electroplating Ships' Bottoms.—Invention has not, it is objected, yet reached the point of adequately protecting a ship's bottom from barnacles and seaweed. "Why not electroplate them with copper?" asks Mr. J. D. Darling, a gentleman well known in conjunction with the large aluminium electroplating contract at Philadelphia. "The first expense," he says, "of course, would be great; but the actual cost of plating a large ship after the first expense for solutions, dynamos, and a suitable dry dock would not be excessive. At first glance there are other objections that appear. The difficulty of keeping a large surface of iron clean until the first coat of copper could be deposited is one. This can be overcome by a plan I used to keep the surfaces of the iron columns for the Philadelphia public buildings clean. They had each a surface of about 300 square feet, but after being pickled and freed from rust and scale, there was no trouble in keeping the exposed iron surface clean and free from oxide until such time as they could be got into the plating-tank, and as they weighed about six tons, this took some time. Another objection is that copper deposited from a solution of sulphate of copper always contains pin-holes, which, of course, would admit the sea-water and set up galvanic action between the copper and the iron of the hull. Also, that the surface of the deposited copper would be rough, and thus interfere with the sailing qualities of the ship. These objections I have overcome by the use of a new plating solution that deposits copper in a much finer and more dense state than that deposited from the ordinary sulphate solution. Copper deposited from this new solution is entirely free from pinholes, and the surface, no matter how thick the coat, is perfectly smooth. It also adheres much better than ordinary plating, which is of great advantage, as there will be less danger of its being torn off by the accidental grounding of the ship in a sand-bar. In fact, there would be little danger of the copper being torn off anyway, as copper, when properly deposited on a clean iron surface, adheres very firmly, and nothing short of striking a rock or other equally hard obstruction, would injure it."

Lighthouse Flashlights.—In a paper dealing with this subject, read on Tuesday before the International Maritime Congress, M. A. Blondel referred to the apparatus called *feux-éclairs* for producing flashlights, designed by M. Bourdelles, and used by the Service Central des Phares de France. This new type of lens, he said, allowed of the realisation of a luminous power hitherto unknown without increasing the intensity of the source of light or the expense of construction. For

electric flash-lights it could not be thought of rigorously proportioning the diameter of the source of light to that of the lens, since that would lead to very considerable sizes for the carbons. The author gave a table, from which, although many of the figures had only hypothetical value, interesting conclusions could be drawn. For instance, for the fourth order (focal length of lens ·30 metre), the light with two panels would only permit of the complete utilisation of the arc light up to 100 amperes; for the higher orders four panels were more than sufficient, and the period of flash being much inferior to the maximum time, there was nothing to prevent a further increase of the intensity of the current, the quantity of additional light so produced being completely utilised. There was then at present no material impossibility in establishing electric flash-lights giving not merely 8,000,000 jets with 100 amperes, as indicated by the table referred to, but even 30 to 40 million c.p. with currents of 400 to 500 amperes, such as often spoken of in England. Such a light placed at a height of 1,000ft. would have a range of 186 miles. Having explained the physiological phenomena which accompanied the vision of instantaneous flashes, and having put forward a rational theory of these phenomena, the author established certain propositions, of which the following may be quoted: (1) Every source of light employed in a lens is capable of furnishing at each flash a quantity of light that only depends on its intensity, and the coefficient of vertical concentration of the apparatus, and on the interval between the flashes. This is fixed by considerations of a practical nature at the value of five seconds. (2) The electric flash-lights could realise the maximum utility at any distance. (3) The range that may be reached with electric flash-lights are now no longer limited by the luminous intensity, but by the height of the tower that would have to be constructed to render them available.

Luminous Power of Lighthouse Apparatus.—M. Bourdelles, Inspector-General des Ponts et Chaussées (France), read a paper on this subject on Tuesday before the International Maritime Congress. He said that the determination of the luminous power of lighthouse lights—that is to say, the useful effects they produced on the eye of the navigator at different distances—had led to numerous investigations in many countries. It had up to the present been agreed in France that the power was equivalent at any distance to that of a naked light of an intensity determined by photometric measurements. It had consequently been represented by a number of carcels decided from laboratory experiments. With regard to the luminous power as dependent upon weather, in more or less foggy weather, when the want of transparency reduced the luminous range to a distance such that the navigator perceived the intrinsic brightness of the apparatus, it was necessary to increase that brightness as far as possible. Under those circumstances, two lights of the same total brightness, but having different intrinsic brightness would be unequal in range and visibility, although they might be equal in ordinary weather. From that point of view, preference should be given to the arc lamp over the incandescent lamp, and to oil burners over gas; similarly to an electric lamp over an oil or gas lamp. For the same reason, with equal luminosity, the apparatus of small dimensions adopted in France for electric lights was superior to those of the second or third order preferred in other countries. It would seem to follow from recent experiments made in England and France that the intrinsic brightness produced by the voltaic arc in electric lighthouses remained constant whatever be the nature of the carbons, their diameter, or distance apart, or whatever be the *régime* of the current. If that was so, the illumination obtained by the apparatus ought itself to be invariable, and the luminous power of an apparatus of a given order would be independent of the electric burner that illuminated it. The dimensions as well as the intensity of the burner would only affect the divergence of the pencil, and it would be immaterial, as regards the luminous range, whether more or less electrical energy was expended. The author, however, observed that photometric measurements of the most unassailable character, made in great numbers in France, on the power of electric light, contradicted those conclusions. They proved, he said, with the utmost certainty that the illumination varied, as if the intrinsic brightness was itself variable and in conformity with the laws governing burners of other kinds.

A Call to Action.—England is within measurable distance of losing much of its prestige as a manufacturing nation unless it look to its affairs; and the reason of this is the advent of electricity. Switzerland, once apparently barred from heavy engineering enterprises by its lack of coal, now stands, by reason of the widespread use of water power, well in the forefront for engineering works of certain kinds. America owes much of the enormous engineering activity of the last few years to the effect of electricity in stirring into action powers of organisation for lighting, for traction, for transmission of power, that had but partially become awakened. The enormous mechanical energies of waterfalls have been seized upon. Niagara, on whose wasted forces envious eyes have long been cast, has at last been tackled, and ere long its power will be transmitted far and wide through the States. What is England doing, one may ask, in this new outbreak of mechanical activity—anything worthy of its heretofore supremacy? A few central stations here and there dotted over its surface; factories whose engine power, in reality, is outweighed by thousands of mills and workshops, of which no note is ever taken. The source of England's greatness has lain in its coal supply, and in the use thereof by its keen-witted practical men. When other countries are learning the lesson of the economical utilisation on a large scale of the water powers they are dowered with, England must readjust the commercial organisation for the use of its source of power—the coalfields. If capital can be secured to dig pits and tunnels for Niagara and other waterfalls, and to erect electrical machinery on enormous scale for the distribution of power; and can find capital to dig pits and tunnels for the raising of coal, it can surely find capital and means of utilising this coal power usefully at the colliery, in the same way that other countries use their water. Fuel under these circumstances would cost but little more than water; the works to utilise it would not necessarily be much more expensive. In the shifting of the balance of power in the world which is apparently going on now, this transportable property of electricity must not be left out of account. We are far too much behindhand in electrical transmission affairs in England. Can we not take the measure of our property, of our needs, of the possibilities of electric transmission, and produce after this hesitation something that shall be of worthy greatness in conception and in execution? The utilisation of the coal at the coalfields is evidently the practical problem of the immediate future, and the difficulties are more those of business organisation by capitalists than of mechanical or electrical disabilities.

High Temperatures.—We alluded last week to the curious experiments of MM. Hoho and Lagrange on the attainment of very high temperatures by using an electrode, as iron, dipping into an electrolyte, such as sulphuric acid.

M. Leroy, in *L'Electricien*, describes some later experiments. The apparatus used is a vessel of glass or porcelain, provided with a sheet-lead electrode, connected to the positive pole of a continuous current generator; the vessel contains sulphuric acid and water. A flexible cable from the negative pole is connected to a strong pair of pliers with insulated handles. Taking in the pliers a piece of metal of any kind, as iron, for instance, and immersing it in the acidulated water, the liquid is seen immediately in ebullition near the metal plate; the plate itself is rapidly heated, brought from red-hot to a dazzling white heat in a few seconds. If the experiment is continued, the heat becomes so intense that the iron begins to melt in spark-like drops; the surface remains constantly brilliant and clean, suitable for welding. The heating is produced so rapidly, locally, that neither the water nor the body of the iron plate have time to become hot, so that when the current is stopped the iron rod or plate—one end of which is incandescent—can be held in the hand. By using a rod of carbon instead of iron, fragments of amorphous carbon are seen dropping off in a few instants, indicating that the temperature has risen to 4,000deg. C. The rapidity of heating depends on the current and other conditions. In the experiments at Berlin the inventors used a current of 220 amperes at 120 volts, the calorific efficiency of the current under these conditions reached nearly 50 per cent. The inventors claim to have actually obtained, with larger currents, a temperature of 8,000deg. C. The explanation given is that the water decomposed electrically, is dissociated still more rapidly under the effect of heat. The oxygen is carried to the positive pole, the lead plate, and produces no effect but a slight oxidation over a considerable surface; the hydrogen, however, being given off round the negative electrode, surrounds it with a sheath of hydrogen gas, which, being a bad conductor, offers great local resistance and gives rise to great heating. The presence of this sheath also explains the clean surface of the metal, which enables it to be so easily welded. The advantages of this method of working metals electrically are apparent. There is another application which these experiments would seem to lead towards—the tempering of one edge or one extremity only of steel cutting tools; and again the hardening of the skin surface of large pieces of metal, such as armour-plates. It is stated that Krupp's are already trying this new method of electric heating for tempering the superficial surface of large guns. Chemical science may also be indebted to this new method of obtaining enormously high temperatures. New dissociations of elements may be brought about, and the artificial diamond, the philosopher's stone of the nineteenth century, may perhaps issue from this intense fire. It is pointed out that the experiments are not entirely novel, as M. Leblond, professor of electricity at the French Torpedo School, two years ago drew attention to the heating of wires in acidulated acid when the pressure is over 60 volts. These experiments were carried on with currents up to 120 volts pressure. This region of experiment seems to offer a fascinating field for further exploration.

An Electro-Cyanide Gold Process.—There are several electro-chemical processes for obtaining gold from refractory ores—that is, ores in which the gold is associated with sulphur, iron oxide, arsenic, antimony, or zinc, and similar deleterious substances. The presence of any of these ingredients acts prejudicially on the mercury used for amalgamation, rendering it sluggish and incapable of seizing upon and retaining the particles of gold. It is to neutralise this effect and to maintain the "quickness" of the mercury, no matter how deleterious the character of the ore, that such processes have been devised and put in practice. It is found, however, that some ores are amenable to one process and some to another, and that no one particular process is available for every class of ore. Hence it is said that expensive plant and machinery is sometimes put up for treating a given kind of ore, and the character of that ore becomes changed so that the process adopted becomes useless and another has to be superadded. To meet such cases and to discover a universal process which should be capable of dealing with every kind of refractory ore, says the *Times*, has long been the study of Mr. J. B. Hannay, F.I.C. He at length appears to have succeeded in his object in a simple and practical manner and by a cheap and expeditious electrolytic process. The main requirements are: (1) The circulation of the pulverised ore between positive and negative poles; (2) a solvent liquid for the gold; (3) means of collecting the electrolysed gold; and (4) the construction of the positive pole. The first requirement is met by having a screw propeller set vertically near the bottom of a tank, so that the powdered ore mixed with water to the consistency of a fluent sludge is agitated by the screw and driven downwards and outwards, up the sides of the tank, and back down the centre again. Rotatory motion of the mass of fluid is prevented by means of a baffle. The solvent is a dilute solution of potassium cyanide, and the collection of the gold is effected by a bath of mercury, which constitutes the negative pole. The positive pole consists of a mixture of powdered plumbago and powdered pitch or resin, these substances being consolidated by heat. This compound is found to set very hard and to form an excellent conductor, a ring of it being placed around the inside of the vat, which is circular. In operation the ore, mixed with a certain proportion of water, is placed in the vat with the bath of mercury at the bottom. On starting the screw, the mixture circulates down the centre of the vat and impinges gently upon the surface of the mercury. It then travels up the sides of the vat, which are conical, and on which the positive pole is laid, and back down to the centre, to be again driven into intimate contact with the mercury. The gold is thus brought into contact with an active instead of a sluggish mercury surface, over and over again, until every atom of gold has been seized and absorbed. The refractory particles of gold are dissolved by the cyanide and at once transferred to the mercury by the guiding power of the current. When the process is complete and all the gold extracted, the sludge is run through a rough filter and the cyanide solution returned to the tank to be used for operating on a fresh charge. The time occupied in treating a batch is put at from two to six hours, according to the character of the ore. It is stated that various kinds of refractory ores, including some typically difficult ones, have been submitted to treatment by this process, with the result that in some cases over 90 per cent. of the contained gold was extracted. The advantages claimed for the process are that the gold is extracted directly from the ore without roasting or any preliminary treatment other than crushing; that the same chemicals are used over and over again; that the process efficiently extracts the gold and silver from the auriferous ores whether refractory or free; that the precious metals are obtained at once from the amalgam in the metallic state, no precipitation or complex chemical methods being required; that any workable quantity may be treated in one vessel at one operation, and the gold obtained in one day. A demonstration of the process was recently given by the Universal Gold Extraction Syndicate, of 73, Basinghall-street, London, at which the apparatus was shown in operation.

ALTERNATE-CURRENT TRANSFORMER DESIGN.

BY R. W. WEEKES, WHIT.SCH., A.M.I.C.E.

(Continued from page 8.)

The three transformers worked out above by no means exhaust the types which have been used by the numerous manufacturers, but after carefully following the methods of design the reader should have no difficulty in working out details for any shape of core or of winding. Care must always be taken that in building up the core, no bolts, or other mechanical parts, form complete circuits embracing parts of the induction through the iron core. Otherwise secondary currents are induced, which add enormously to the losses.

The only remaining type which requires distinct treatment is the Hedgehog, an open-circuit transformer introduced by Messrs. Swinburne and Co. In this case the iron circuit is not closed, and the whole of the induction has to return from one end of the core to the other by the air. The advantage claimed for this transformer was that it had less iron loss than any ordinary closed circuit transformer. This has been proved to be a fallacy by Dr. Fleming's measurements on a three and a six kilowatt transformer, which had no-load losses as great as most closed-core types. He also showed that the manufacturers have been misled by a wattmeter which gave low power reading on inductive circuits. The grounds of the statement that there is less iron loss appears feasible at first sight. Suppose the transformer last designed was taken, Fig. 21, and the iron yokes were cut away just after the bend. This would reduce the weight of iron to one-half its former value. Then, if the same induction were used, the iron loss should be halved. But for the fact that the core is rectangular, we should now have a Hedgehog.

Figs. 22 and 23 shows the construction of this make of transformer. The core consists of thin iron wire stiffened by a gunmetal casting, which forms the support for all attachments. The iron wire is laid in between the flanges of this, and then bound tightly up with twine. Wooden flanges to support the copper wires are slipped on over the core. The winding of the coils is carried out much in the same way as described in other cases but for the fact that they are wound *in situ*, and that two sets of secondary winding are used, one each side of the primary. The ends of the wire core are spread out after the wooden flanges have been passed over them. The object of this spreading is to decrease the magnetic leakage along the core as much as possible.

The first abnormal point requiring notice is the large no-load current required. Thus, in the six-kilowatt tested by Dr. Fleming, the no-load current was 47·5 per cent. of the current required to furnish six kilowatts at the normal voltage of the primary. The actual loss at no load was 2·75 per cent., so that the current required to magnetise the iron, i_μ, is $\sqrt{47{\cdot}5^2 - 2{\cdot}75^2} = 46{\cdot}6$ per cent., and

$$\frac{i_\mu}{i_h} = \frac{46{\cdot}6}{2{\cdot}75} = 17.$$

Now, in the closed-circuit transformers designed above, this ratio was slightly greater than unity, and in many transformers with superior brands of iron it falls below unity. The high value of i_μ in the Hedgehog transformer is due to the air resistance in the return path of the magnetic lines.

Again, it will be noticed that the iron loss was 2·75 per cent. of the total output, whereas if the transformer, Fig. 21, had its iron reduced by cutting away the yokes, the loss would be only 1·25 per cent. This, of course, may be explained by assuming that in the Hedgehog transformer the iron is worked at a much higher induction, but it is likely to be due to causes peculiar to the type. The lines of force in this transformer are supposed to flow along the full length of the iron and then to return by the air, and the turning back of the wire core at the ends does much to ensure this. Still, lines of force do leak out before the ends are reached to a much greater degree than occurs in any closed circuit transformer. The result is that to maintain the same E.M.F. in the wires, the total flux in the central sections has to be increased to make up for the smaller flux cutting the end conductors. Although the mean induction may be the same, the higher density in the centre will increase the total iron loss more than the diminution of density at the ends reduces it. Then, too, the leakage lines have to pass through the copper, and in so doing may cause eddy currents to an appreciable amount. These causes are likely to account for the no-load loss being considerably higher than would be expected from the quantity of iron used.

Fig. 22.

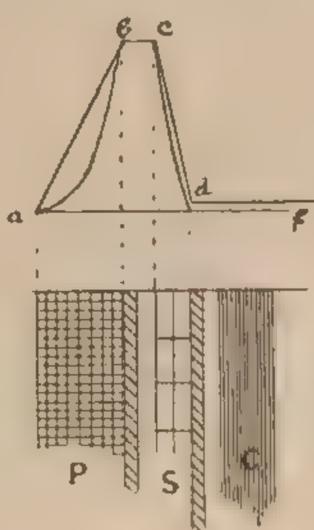


Fig. 24.

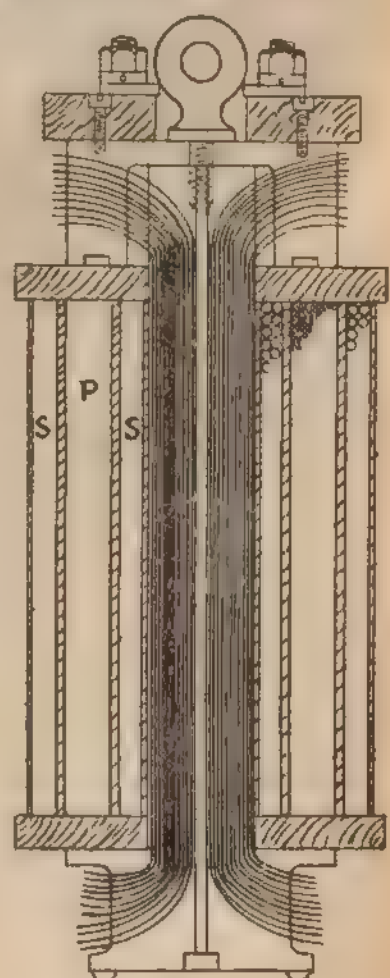


Fig. 23.

The large current at no load is the great disadvantage of this type, because although wattless in the transformer it causes losses in all the conductors. Also, it heats the alternator armatures as much as if the apparent power were being actually supplied. Thus, if a station were equipped solely with Hedgehogs, at least 40 per cent. of the plant would have to be run continuously. The method suggested of overcoming this disadvantage is that of using condensers in parallel with the transformers to supply this large current. The dielectric losses in the condensers then have to be considered, and they are far from negligible. Even if the open circuit have the advantage claimed of little or no load loss, it does not follow that it is better than a closed circuit; for if two such transformers are taken and placed side by side, the iron at the ends would need a very slight increase of length in order to complete the iron circuit through the two. The result is a closed-circuit transformer of twice the

output and about twice the iron loss. This loss will be reduced below the sum of the two individual transformer losses, owing to the uniformity of induction resulting from the completion of the iron circuit. The current at no load would of course be reduced to the normal amount required by a power factor of, say, 70 to 80 per cent.

Large transformers are expected to be more efficient than small ones, but still the combination thus made will show at once the advantage of having a closed core.

Magnetic Leakage of Transformers.—This branch of the subject is one that cannot be satisfactorily treated by calculation alone, and even when aided by previous experiments it is not easy to predict accurately the leakage effects in a new design. When a transformer is working a full load, the internal reactions cause fewer lines of force to pass through the secondary than through the primary, and hence we find a larger drop of volts than can be accounted for by loss in the copper. It is usual to deduct the known C R losses, and to call the remaining drop in pressure "magnetic leakage." When a transformer is working light the primary supplies the current necessary to magnetise the core and the secondary has no current in it, hence the action is simple and there is no differential magnetising effect. Now at full load in the third design the primary current has increased to 26·5 times its previous value, and we have the secondary current opposing the magnetising force of the primary. At no load, the magnetising force just inside the primary due to i_μ (·0864 ampere) would be $\frac{i_\mu \tau \, 1{\cdot}76}{l}$, where τ = the turns per coil, and l = the length of the coil.

$$\therefore H = \frac{{\cdot}0864 \times 865 \times 1{\cdot}76}{23{\cdot}5} = 5{\cdot}6 \text{ in C.G.S. measure.}$$

So that the induction in the air would be very small—*i.e.*, 5·6—compared to that in the iron. At full load the current rises to three amperes; so the magnetising force in the air space just inside the primary will now be

$$\frac{3 \times 865 \times 1{\cdot}76}{23{\cdot}5} = 195.$$

This will give an induction of 195 lines per centimetre, which, when multiplied by the area, gives a leakage flux which is appreciable.

The action is not confined to the actual space between the windings, but extends into the wire. Thus, in Fig. 24 the values of H are plotted over a section of the winding space. The magnetising force rises to its maximum value just inside the primary winding, and maintains this value till the secondary current causes it to fall. Halfway through the primary the force will be half the maximum, but as half the turns only are cut by the leakage lines generated here, the effect, if considered as acting on the whole number of turns in the primary, will be represented by half the ordinate at this point. Proceeding in this way, we get the total equivalent leakage effect, each point which is represented graphically by the curve lying under the lines, *a*, *b*, *c*, *d*. The area included between this curve and the abscissa, *a*, *f*, represents the total leakage flux when multiplied by the mean perimeter and constants depending on the scale to which the curve is drawn. This figure represents the number of C.G.S. lines which are acting on the primary only. It will be found that the flux thus obtained is a larger percentage of the total flux than the drop due to magnetic leakage is of the total voltage. This is because the leakage field thus summed up is in quadrature with the induction in the iron. Hence its effect must be worked out as acting at right angles to the flux in the iron. When this has been done, an approximate figure will be obtained generally underestimating the leakage, because no notice has been taken of the return path of these leakage lines. With careful consideration of all these points, it is possible to obtain a fair approximation to the leakage effect, but when working on one given type experiments give a more valuable guide. It is better in working out transformers to obtain the number of ampere-turns per given length of leakage path, and then by comparison with previous experiments to determine the probable leakage effects. When measuring the magnetic drop, great care must be taken that the circuit used for the load has neither induction nor capacity in it. Otherwise the results will be practically useless. Very little capacity will completely annul the drop, and, on the other hand, induction increases it.

In connection with leakage it must be clearly remembered that it is only alteration in magnetic flux due to the secondary current that causes bad regulation. Leakage of the induction in the core across to the yokes, such as is found in all magnetic circuits, has no harmful effect on the regulation. Thus the Hedgehog transformer virtually has the return path of the magnetic lines as leakage, and yet it regulates as well or better than many closed circuits. This is due to the fact that the differences between the magnetising force of the primary at no load to its value at full load is nearly 3 to 1 instead of 26 to 1, as in the transformer above. This leakage, which does not affect the regulation, may, however, be very harmful in causing eddy currents in both iron and copper, and a Hedgehog transformer made with a core of iron plates would show this at once by giving a larger iron loss than with the wire core.

(To be continued.)

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC.MEM.INST. ELECTRICAL ENGINEERS.

ARC LIGHTING.

(Continued from page 29.)

Fixing and Trimming.—The structural arrangement of a building has a great deal to do with the hanging of arc lamps, since the positions in which the lamps are placed are mostly regulated by the position of the girders, columns, etc., so that they must not be hung anyhow and anywhere. When determining these positions, provision must be made for getting at the lamps easily and quickly for repairs, trimming, cleaning, etc.; difficulty of access causes loss of time and loss of money, and, in addition, is often a perpetual source of annoyance to the occupiers of the place that is lighted. Buildings that are roofed by a lofty arch are particularly troublesome to deal with. Take the case of a railway station as an example, where the span is built of iron and glass. This must be wired without incurring the enormous expense of using scaffolding, and calls for a fair amount of activity and nerve on the part of those engaged in the work. The lamps should in these cases be fixed on either side of the centre of the arch, that is if the lighting arrangements allow of this being done. Another matter of importance, and one that will give plenty of scope for carrying out ingenious plans, is to wire the place in such a way that the length of cable used is brought down as low as possible. A vast amount of cable can be wasted on jobs of this sort, unless a good economical wiring scheme is thoroughly thought out. Great precautions must be taken that there is good insulation everywhere. When running cable along iron girders, etc., porcelain insulators must be freely used, so that at no point does the cable come in contact with the ironwork.

Arc lamps are best hung with steel ropes—No. 8 will do; and since it is a common thing for them to have the negative cable connected to the metal framework of the lamp, therefore the steel rope must pass through an insulator. In place of the iron hook at the top of the framework some lamps have a little porcelain pulley.

Every lamp is provided with a cut-out switch by means of which the lamp can be cut out of circuit. Should it be necessary to handle the lamp in any way when the current is on the circuit, it is of the most vital importance that the trimmer should switch that particular lamp out of circuit before attempting to touch it; it is only the work of a second, and personal safety is then ensured. Through neglect of this simple precaution several fatal accidents have taken place—all owing to gross carelessness on the part of the trimmer; because this is a most rigid rule in all arc light central stations, and need be so, when it is remembered that the working pressure is often 3,000 volts or so. An arc lamp can be hung, "fixed" or "movable." In the former case, the trimmer has to carry

trestles from lamp to lamp, which involves a good deal of labour and loss of time. This is speaking of indoor lamps For outdoor lamps, such as those for street-lighting, the trimmer only needs a light ladder, because the lamps are fixed on standards or projected from walls.

By going to a little more expense, indoor lamps can be made movable by using a lowering gear with a counter weight. In this case the lamp can be drawn down to the floor for trimming, etc, and then shot up again; the one objectionable feature of this method is the presence of the "slack cable." A 10-ampere cable, well insulated, is about as thick as one's thumb, and when banging loosely has an unsightly appearance; to avoid this, several devices have lately been brought out to automatically wind and unwind this slack as the lamp is moved up and down.

An arc lamp should never be suspended by means of its own cables. The weight of the lamp should in all cases be taken by a means of suspension perfectly independent of the cables, and when the lamp is at its proper position the cable should have no more tension in it than to give a fairly taut and trim appearance.

When lamps are hung from posts, out of doors, in exposed positions, it is necessary to fasten the bottom of the lamp to its support, otherwise it will sway about in a high wind.

Putting a fresh pair of carbons into a lamp, to replace those which have burnt away, is called "trimming," and the man who attends to this duty and looks after the lamps generally, is called a lamp trimmer. In trimming, great care must be taken that the two carbons are put in their holders so that they are perfectly in line. The carbon-holders are made adjustable in most lamps, so that they can be shifted about. When a carbon does not fall in line, it will often be found that simply turning the carbon round a little will make it right. When trimming a lamp, always put in the positive first, and then allow the lamp to run down slowly. If the carbon is fixed right, it will glide through the aperture of the negative carbon-holder, thus proving that this one is centrally fixed; it only remains now to fix the negative so that its point is opposite the point of the positive. The brass rods of the lamp should never be cleaned with emery-cloth, because the constant rubbing would produce wear and the adjustment of the lamp would be spoilt; only paste should be used; at times when the rods have become very dirty, a little crocus-paper might be used, but only sparingly. Lamps that are fixed in foundries, smelting works, and all such places of this sort, get smothered with grime and dust. The mechanism of such lamps should be well covered up. When lamps are fixed anywhere near to the sea, such as on the promenades of seaside places, if they are only used for the summer season, they should be taken down and stored away when the season is over. When in use they will require well looking after, because they are exposed to stormy weather, and the sea-brine in the atmosphere tends to rust the mechanism of the lamp. The cables should always be buried underground if possible, or, at least, protected as much as possible from the atmosphere, and, in particular, they should be placed where no sea-water or sea-spray can wet them.

Running in Parallel.—In an incandescent system of lighting it is very often required to run a few arc lamps. The lamps are then run two in series across the mains—any number of pairs of lamps can be run like this. When the pressure is above what is required for two lamps in series the surplus is absorbed by a small resistance coil placed in series with the lamps, so that the electrical power consumed by the pair is the product of the circuit pressure into the current the lamps take; of this power, evidently that absorbed by the resistance coil is wasted. For example, suppose we have a number of incandescent lamps working at a pressure of 110 volts—two "full" arc lamps take about 10 amperes—and a pressure of, say, 42 volts each, there is then $110 - 84 = 26$ volts left, and since the same current passes through both lamps and resistance coils, therefore $26 \div 10 = 2.6$ = the resistance, in ohms, that the resistance coil must have in order that 26 volts shall be absorbed in forcing a current of 10 amperes through it, because $10 \times 2.6 = 26$. The above figures relate to some arc lamps run off an incandescent plant now *at work*. Lamps that are run in parallel always burn better when there is a good margin of pressure, even though this extra pressure is absorbed by a resistance. To run a single lamp on an incandescent circuit would require a large resistance coil unless the circuit had a very low pressure, such as 70 volts, so that for the usual pressure of incandescent circuits, 100 or 110 volts, as much power would be wasted in the resistance coil as would run a second lamp.

In the event of one of the two lamps that are run off the mains going out, or otherwise failing to act, the second one goes out as well, there being no cut-out as a rule on lamps adapted for parallel running; the reason of this is that the remaining lamp would have double the pressure, and hence its current would be doubled, which would at least damage the regulating coils of the lamps, and in all probability burn them up.

(To be continued.)

MUNICIPAL ELECTRICITY WORKS.*

BY ROBERT HAMMOND, M.I.E.E.

Whoever essays to bring the subject of municipal electricity works before the municipal and county engineers of England must do so with some feeling of trepidation, for if proved that such works ought to be universally established, there will be thrust upon the shoulders of, perhaps, the hardest worked body of gentlemen in the United Kingdom a new and onerous responsibility. The writer, as an excuse for his temerity, presumes that in each case where the management of the municipal electricity works is committed to the care of the borough engineer, the ratepayers will, with their usual generosity, take care that this gentleman is enriched with a portion of the profits arising therefrom.

Before dealing with the question from a municipal point of view, a few minutes may profitably be devoted to the history of the establishment of the electricity supply industry in this country Up to the year 1879 very little electric lighting of any kind was done in the United Kingdom, but the introduction in that year of a new arc dynamo which was a sound engineering job, and which could run for long spells without breaking down caused quite an outburst of activity. The result was that almost all large works which were in operation by night as well as by day, adopted electric lighting. In some, the electricity was "generated" at a centre for distribution over a large area, and thus the idea of central stations became familiar Public lighting was started in the metropolis and elsewhere, but in the early eighties there was no "private lighting" to bear its share of the standing charges, and the public lighting contracts, being taken at a loss for the sake of advertisement, were, in almost every case, not renewed on their expiry. In three places in England, however—Brighton, Eastbourne, and Hastings—public-spirited and plucky individuals kept the central stations at work, and, adopting the rough means then available for running incandescent lamps on arc circuits, gave the customers the choice of arc or incandescent lighting, and, by the actual experience of years, exemplified the ease with which incandescent electric lighting over an extended area from one centre could be accomplished. At Brighton, from the beginning the supply was by means of overhead wires; but at Eastbourne and Hastings the distribution from the very first was effected by means of underground mains. The companies established in these places were followed by others formed by private enterprise at Liverpool, Sheffield, Bournemouth, and Bath, in the provinces, and at the Grosvenor Gallery and Kensington, in the metropolis.

On the passage of the Electric Lighting Act of 1882, 14 local authorities obtained provisional orders, but until 1889 not one of them was put into force. In that year the first municipal electricity works were opened at Bradford, and these proving successful, municipal electricity works are now in operation in nine places, embracing districts so widely different as St. Pancras, Dublin, Brighton (undertaken in order to prevent a local electricity company from getting a provisional order), Hull, Nelson, and Glasgow.

To give a clear idea of the present position of electricity supply in the United Kingdom, there follows a tabulated statement of the works holding statutory powers at present in operation, the capital invested being set out and a discrimination made between those works situated where the gasworks belong to the corporation and where they belong to a company. This (Table A) is not confined to works belonging to local authorities, because the amount of capital already invested in the industry by private enterprise, as indicating the opinion

* Paper read before the Incorporated Association of Municipal and County Engineers at the annual meeting at West Bromwich, July 13, 14, 15, 1893.

of capitalists, has a very important bearing on the question of the soundness of the electricity supply industry

TABLE A.—ELECTRICITY WORKS (HOLDING STATUTORY POWERS) IN ACTUAL OPERATION IN THE UNITED KINGDOM.—Statement of Capital Invested on June 30, 1893 ‡

Date of starting supply.	Name of place.	Supply by Companies. Gasworks owned by a company.	Supply by Companies. Gasworks owned by local authority.	Supply by Local Authorities. Gasworks owned by a company.	Supply by Local Authorities. Gasworks owned by local authority
		£	£	£	£
1882	Eastbourne	37,119*	—	—	—
[illegible]	Hastings	20,745*	—	—	—
1884	Liverpool	186,439†*	—	—	—
1887 to 1889	The metropolis companies	3,323,552	—	—	—
	Local authority, St. Pancras	—	—	100,000	—
1888	Sheffield	20,000	—	—	—
1889	Bournemouth	38,625*	—	—	—
,,	Bradford	—	—	—	69,800
,,	Bath	38,340	—	—	—
,,	Taunton	—	—	16,000	—
1890	Newcastle-on-Tyne	75,105*	—	—	—
,,	Exeter	20,100*	—	—	—
,,	Birmingham	—	70,000	—	—
,,	Chelmsford	10,000	—	—	—
,,	Chatham	20,000	—	—	—
1891	Brighton Corporation	—	—	73,200	—
,,	Northampton	15,000*	—	—	—
,,	Southampton	12,645	—	—	—
,,	Fareham	4,158	—	—	—
1892	Preston	53,025	—	—	—
,,	Dublin	—	—	40,000	—
,,	Hove	15,500	—	—	—
,,	Nelson	—	—	—	10,000
,,	Oxford	62,520*	—	—	—
,,	Morecambe	4,781	—	—	—
1893	Hull	—	—	35,000	—
,,	Leeds	—	56,000	—	—
,,	Glasgow	—	—	—	100,000
,,	Dundee	—	—	—	30,000
	Totals	£3,967,654	£126,000	£264,200	£209,800

* These figures include debentures or loans. † December 31, 1892. ‡ There is excluded from this and the remaining tables the various works, mostly on a small scale, scattered throughout the country which are not working under statutory powers.

The works are arranged in the order of their date of starting the supply. The pioneer works are those at Eastbourne. The works owned by the private company at Brighton, established in 1881, would head the list, but they are excluded because the company there is working by means of overhead wires, without statutory powers. It will be seen that the total capital invested at the present time in statutory electricity works actually in operation is £4,557,654, which is contributed as follows:

SUMMARY OF TABLE A. *Electricity Works (with Statutory Powers) in Actual Operation.*

Owned by	Capital invested.
Companies	£4,083,654
Local authorities	474,000
Total	£4,557,654

In only two cases, where the gasworks belong to the Corporation—*i.e.*, Birmingham and Leeds—have the local authorities allowed a provisional order to go into the hands of a company. It is a matter of importance in these cases to consider the terms of purchase which are embodied in the provisional order sanctioned by the local authority. The Leeds terms are as follows: The Leeds Corporation has the right of taking over the works and business of the company

(*a*) At any time prior to July, 1901, by the issue to the company of such an amount of Leeds Corporation stock as will produce by the interest or dividends thereon an annuity of 5 per cent. per annum upon the sum expended by the company upon their undertaking and chargeable to capital account, and also the payment to the company of a sum equal to the aggregate amount of a dividend of 5 per cent. per annum on the said capital expenditure, less the aggregate amount of the dividends declared by the company up to the date of purchase.

(*b*) At any time from July, 1901, to July, 1912, by the issue to the company of such an amount of Leeds Corporation stock as will produce by the interest or dividends thereon an annuity of 5 per cent. per annum upon the capital account of the company. N.B.—For instance, if at the date of such purchase the capital so expended were £50,000, the company would receive sufficient Corporation stock to produce £2,500 per annum, the market value of which is now about £80,000.

(*c*) At any time between July, 1912, and July, 1922, either on the above named terms (*b*) or upon the Corporation paying the company the then value of the undertaking in accordance with Section 2 of the Electric Lighting Act, 1888, together with such additional sum as may be determined by arbitration to be the value of the goodwill of the undertaking.

(*d*) After the expiration of July, 1922, or at the end of every subsequent period of seven years, either on the terms of (*b*) or upon the Corporation paying the company the then value of the undertaking in accordance with Section 2 of the Electric Lighting Act, 1888; but the option of purchase on the terms of (*b*) ceases in 1933.

In addition to the electricity works already in operation, there are 25 new works for which contracts have been given out, and these are tabulated in the same form as the above:

TABLE B.—ELECTRICITY WORKS IN COURSE OF CONSTRUCTION IN THE UNITED KINGDOM.

Name of place.	Supply by Companies. Gasworks owned by a company.	Supply by Companies. Gasworks owned by local authority.	Supply by Local Authorities. Gasworks owned by a company.	Supply by Local Authorities. Gasworks owned by local authority.
	£		£	£
Aberdeen	—	—	—	20,000
Blackpool	—	—	—	31,000
Burnley	—	—	—	23,500
Burton-on-Trent	—	—	—	25,000
Bristol	—	—	66,000	—
Cardiff	—	—	32,500	—
Cambridge	23,180	—	—	—
Dewsbury	—	—	—	25,000
Derby	—	—	30,000	—
Ealing	—	—	25,000	—
Huddersfield	—	—	—	50,000
Hanley	—	—	21,000	—
Hampstead	—	—	25,000	—
Kingston-on-Thames	—	—	16,000	—
Lancaster	—	—	—	25,000
Londonderry	—	—	15,000	—
Leicester	—	—	—	50,000
Manchester	—	—	—	150,000
Norwich	14,226	—	—	—
Oldham	—	—	—	27,000
Portsmouth	—	—	56,395	—
Richmond	20,000	—	—	—
Scarborough	22,000	—	—	—
Worcester	—	—	39,109	—
Whitehaven	—	—	—	14,000
	£79,406	Nil.	£325,994	£440,500

TABLE C.—ELECTRICITY WORKS DECIDED UPON (BUT CONTRACTS NOT YET GIVEN OUT) IN THE UNITED KINGDOM.

Name of place.	Supply by Companies. Gasworks owned by a company.	Supply by Companies. Gasworks owned by local authority.	Supply by Local Authorities. Gasworks owned by a company.	Supply by Local Authorities. Gasworks owned by local authority.
	£	£	£	£
Accrington	—	—	10,000	—
Bournemouth	—	—	3,200	—
Bolton	—	—	—	40,000
Blackburn	—	—	—	50,000
Belfast	—	—	—	50,000
Coventry	—	—	—	15,000
Croydon	—	—	25,000	—
Edinburgh	—	—	100,000	—
Fleetwood	—	—	10,000	—
Halifax	—	—	—	30,000
Islington	—	—	60,000	—
Lambeth	—	—	75,000	—
Newport, Mon	—	—	30,000	—
Nottingham	—	—	—	45,000
Reading	25,000	—	—	—
Southport	—	—	—	28,000
Salford	—	—	—	50,000
Shoreditch	—	—	63,000	—
Stafford	—	—	—	30,000
Wolverhampton	—	—	28,772	—
Walsall	—	—	—	25,000
Yarmouth	—	—	15,000	—
York	—	—	25,000	—
	£25,000	Nil.	£444,972	£363,000

It will be seen that in the case of these new works none are being erected by companies in localities where the gasworks belong to the corporation, and that the amount of new work which companies have in hand bears only an insignificant proportion —10 35 per cent.—to that of local authorities.

SUMMARY OF TABLE B.—*Electricity Works in Course of Construction.*

Owned by	Capital invested.
Companies	£79,406
Local authorities	766,494
Total	£845,900

which sums, added to those given above (Table A), result as follows:

TABLES A AND B (COMBINED).—*Electricity Works in Operation and in Course of Construction.*

Owned by	Capital invested.
Companies	£4,163,060
Local authorities	1,240,494
Total	£5,403,554

But even this figure does not exhaust the budget, for there are 22 places in the United Kingdom in which statutory powers have been obtained and electricity works decided upon, but where the contracts have not yet been given out (Table C).

Again, note the great disparity in value of the new works 3·1 per cent.—decided upon by companies and by local authorities.

SUMMARY OF TABLE C.—*New Electricity Works Decided Upon.*

Owned by	Capital invested.
Companies	£25,000
Local authorities	807,972
Total	£832,972

Leaving the grand totals of

TABLES A, B, AND C (COMBINED).—*Electricity Works (with Statutory Powers) in Operation, in Course of Construction, and Decided Upon.*

Owned by	Capital invested.
Companies	£4,188,060
Local authorities	2,048,466
Total	£6,236,526

After this batch of figures, perhaps, no more should be inflicted, though to epitomise the exact position at the moment one should add a list of places where electricity supply is under discussion, but where no decision has yet been come to (Table D).

TABLE D. — ELECTRICITY WORKS PROJECTED BUT NOT YET DECIDED UPON IN THE UNITED KINGDOM.

Name of place.	Supply by Companies. Estimated cost.		Supply by Local Authorities. Estimated cost.	
	Gasworks owned by a company.	Gasworks owned by local authority.	Gasworks owned by a company.	Gasworks owned by local authority.
	£	£	£	£
Aberystwith	—	—	10,000	—
Altrincham	10,000	—	—	—
Barnet	—	—	10,000	—
Beckenham	—	—	10,000	—
Bridgend	—	—	10,000	—
Bromley	—	—	20,000	—
Buxton	—	—	-	10,000
Bow	—	—	20,000	—
Bury (Lancs.)	—	—	—	30,000
Bedford	20,000	—	—	—
Carlisle	—	—	—	20,000
Canterbury	15,000	—	—	—
Chester	—	—	20,000	—
Chiswick	10,000	—	—	—
Colchester	—	—	10,000	—
Dover	—	—	15,000	—
Eccles	—	—		20,000
Falmouth	—	—	20,000	—
Folkestone	—	—	20,000	—
Hackney	—	—	25,000	—
Hammersmith	—	—	30,000	—
Hertford	—	—	10,000	—
Haddington	—	—	—	5,000
Llangollen	—	—	45,000	—
Llanelly	—	—	10,000	—
Maidstone	10,000	—	—	—
Moffat	—	—	—	5,000
Morley	—	—	30,000	-
Merthyr	—	—	10,000	—
Newmarket	15,000	—	—	—
Oswestry	10,000	—	—	—
Orpington	10,000	—	—	—
Partick	—	—	15,000	—
Poplar	—	—	25,000	—
Perth	—	—	—	20,000
Peterborough	10,000	—	—	—
Paisley	—	—	—	15,000
Pontypool	10,000	—	—	—
Redditch	—	—	15,000	—
Sutton	—	—	15,000	—
St. Lukes	—	—	25 000	—
St. Albans	—	—	10,000	—
Sunderland	—	—	20,000	—
Tunbridge Wells	—	—	25,000	—
Twickenham	—	—	15,000	—
Wigan	—	—	—	50,000
Wrexham	15,000	—	—	—
Weston super-Mare	—	—	20,000	—
	£135,000	Nil	£510,000	£175,000

The above figures are significant. They indicate (1) that there is a consensus of opinion in favour of the establishment of electricity supply works; (2) that though the bulk of the pioneer work has been done by private enterprise, the newer works are almost all being undertaken by local authorities; (3) that with only two exceptions has any local authority owning the gasworks sanctioned the granting of statutory powers to a company.

Let us now consider whether the attitude of so many local authorities can be justified upon sound municipal and commercial grounds.

I.—MUNICIPAL POINT OF VIEW.

It would be out of place if, in connection with the subject of electricity supply, we embarked in a discussion as to the advisability of municipal trading. That has been thoroughly thrashed out in connection with water and gas supply; and it is now universally acknowledged that local authorities can with propriety become the distributors of these two commodities.

Pure water is the prime necessary of human life, and, though this cannot be said of gas, with regard to both it may be urged that (*a*) they are practically in demand by the whole body of ratepayers; (*b*) they are supplied, in any particular locality, to all consumers alike, whether rich or poor, in one uniform quality.

Let us apply these tests to electricity supply. (*a*) *The demand* may certainly be regarded as *universal*, the only limit to it being the question of price. (*b*) The supply to every ratepayer, as in the case of water and gas, is bound to be uniform in quality.

Price will be dealt with under the next head, and setting this aside for the moment, it would appear that, from the municipal point of view, electricity supply is on exactly the same basis as water and gas supply. But in the case of both the latter the undertakings have, almost universally, been started by private enterprise, and subsequently acquired by local authorities when they were assured successes. Is there anything connected with *electricity supply* that should make such a course inadvisable?

Let us first consider to what extent, if any, the ratepayers are prejudiced by the operations of a company. If a local authority sanction a provisional order on behalf of a company, the first step of the company is to select a compulsory area, limited in extent, but comprising the choicest portion of the town from the electric lighting point of view. Ratepayers inside this area are able, by the use of the electric light, to make their places of business more attractive, to the detriment, probably, of the ratepayers outside, who cannot demand a supply for two years, and can then only obtain it under onerous conditions of guarantee, etc.

How does this arrangement appeal to the town authorities, who are the guardians of the interests of the whole of the ratepayers and not of a select few? Presuming that a fair case can be made out for electricity supply from the commercial point of view, it should surely be the aim of a local authority to establish works in connection with which a supply is placed at the disposal of the whole of the ratepayers. No company, however, would accept so onerous a condition as making the whole city or borough the compulsory area; whereas, in the case of the local authority being the undertaker under the Electric Lighting Acts, the whole city or borough practically becomes the compulsory area.

It may, however, be urged that if a profitable demand present itself outside a company's compulsory area the company will, as a mere matter of business, extend its mains and enlarge its works. But in the hands of a company the growth of the undertaking must necessarily be slow. The shareholders, believing in quick returns, insist upon immediate and good dividends as the precursor to an enlargement of the capital account.

The business is, therefore, often cramped for capital from the beginning, and the unfortunate ratepayers in the "outside area" are left in the lurch. A municipality can afford to take wider views. If the business be in itself sound, its aim is to develop it on an extended basis as rapidly as possible. A local authority can afford to make "capital extensions" without waiting for a 5 or 6 per cent. return upon the work in the compulsory area; its principal aim being, with due regard to permanent profitable results, to extend the benefit of electricity supply throughout the whole of the district under its control. Again, it is obvious that the quickest way of developing the business is to offer the supply at a cheap rate. Bradford, for instance, is charging 5d per unit, equivalent to 2s. 6d. to 3s. per thousand feet of gas; St. Pancras, 6d. for light and 3d. for motor supply; Burton-on-Trent, 6d., etc. No companies, except those at Newcastle-upon-Tyne, have ventured upon starting with such low rates of charge as this. Far-seeing directors may be fully alive to the fact that such a bold policy is the best; but they fear the criticism of the timid shareholder, who might object to lean profits in the early stages of the business.

To bring my remarks under this head to a close, I will only refer to one other municipal consideration. It is often said that in the early period of the establishment of municipal electricity works the demand will not be universal, and the works possibly conducted at a loss, and that it is unfair that the whole of the ratepayers should incur a responsibility for the benefit of a comparatively limited number. It must, however, be remembered that the introduction of electricity supply to any town raises the status of that town, and indirectly results in a benefit to the whole of the ratepayers. Large sums are constantly being voted, with scarcely a murmur for the improvement of sanitary conditions; and the day will probably arrive, when before this very association, a paper will be read on the iniquity of the nineteenth century in permitting the distribution, by constantly leaking pipes, under the public streets, of such a frightfully noxious thing as coal-gas, and in encouraging the illumination of interiors with that which only gives out light by robbing the air of its life-giving quality—oxygen—and by returning to the air poisonous carbonic acid, to the marked lowering of the standard of health.

Ten years ago the writer, in his "Electric Light in Our Homes,"* pleaded, before the establishment of a single electricity supply works under statutory powers in this country, for the universal use of the electric light for interiors, and the arguments set forth then, now regarded as platitudes, are as strong as ever. The perfect light must fulfil the following conditions:

(1) Not feed on the air; (2) add no noxious fumes to the air; (3) give off no appreciable heat; (4) be free from danger of causing fire; (5) not injure a tradesman's stock; (6) do no damage to ceilings, furniture, etc.; (7) not injure the sight; (8) be quite reliable; (9) not escape; (10) be absolutely free from danger to life or limb; (11) be convenient, capable of being measured and economised, and arranged artistically.

It is in the hands of our municipal authorities to beautify their towns by the introduction of such a perfect light, and to place it within the reach of every ratepayer.

We will now turn to the consideration of the

II.—Commercial Point of View.

Until quite recently "electrical finance" has been under a cloud in consequence of the fruitless outburst of speculation which characterised the pioneer days of the industry. It cannot too often be repeated, however, that the money lost in 1883-84 was not lost in "electricity supply." Indeed, it may be stated that not one single concern holding statutory powers which has fairly embarked on its course, has come to grief. The large sum of four millions invested by the present supply companies in electricity works indicates pretty clearly the opinion of the commercial world as to the soundness of the industry. The following table shows the margins, on the right side, between costs of working and revenue as exemplified by the 1892 balance-sheets of 15 electricity works:

Name of works.	Margin between total costs and revenue.	On a capital of	Per cent. of margin to capital.
Birmingham	£3,488	£70,000	4·98
Bradford	1,476	34,243	4·31
Charing Cross	10,247	200,900	5·10
Chelsea	4,319	80,585	5·36
Eastbourne	1,746	37,119	4·70
House-to-House	2,830	76,795	3·69
Kensington	10,327	154,400	6·68
Liverpool	15,993	186,409	8·58
Metropolitan	18,168	549,741	3·30
Newcastle and district	2,140	33,240	6·43
Newcastle-on-Tyne	2,300	40,699	5·65
St. James	18,329	200,000	9·11
St. Pancras	2,576	91,269	2·82
Westminster	14,508	370,000	3·92
Brighton	2,229	52,563	4·24

* London. Fredk. Warne and Co., 1883.

It will be noticed that in almost all the above cases there is sufficient margin between the costs of production and the revenue to provide for the annual sinking fund required to repay the electric light loan, if the supply were in the hands of the local authority. The General Purposes Committee of the Birmingham Town Council have, however, just reported "that at present at all events the profits made from the supply of electricity are inconsiderable"; but they overlook the highly important fact that the bulk of the works in operation are only in the initial stage, and as they develop and the demand increases they will work at much cheaper costs and show much more substantial margins between costs and revenue. The increase in the demand, however, will largely depend upon the possibility of being able to directly compete with gas in price, for though we cheerfully pay more for newly-laid eggs than for "shop un's," the greater number of householders, as a rule, are compelled by stern financial necessity to give the preference to the less desirable article on account of its cheaper price. These will for like reasons continue to use the filthy poisonous gas until electric light comes within the range of their limited purses. What chance is there of such a happy consummation? By a wise provision of the Board of Trade, each "undertaker," under the Electric Lighting Acts, is compelled annually to file its complete accounts, and to set forth in detail its cost of production. These costs are regularly analysed in *Lighting*, a periodical which may be known to you, and that analysis need not be repeated here; but it may be noticed that, excluding the metropolis, where the conditions of production and supply are in many cases abnormal, there are works whose total costs of production are as low as Bradford, 4·04d.; Liverpool, 4·25d.; Newcastle, 3·48d. and 3·43d. per Board of Trade unit, so competing with gas at 2s. to 2s. 6d. per thousand feet. These costs cannot, however, fairly be compared with those of gas, because they are on the basis, as compared with gas, of a very limited production. It is fair to assume that when electrical energy is produced on the same scale as gas it will directly compete with it in price. One important feature in this connection is the series of improvements which are certain to occur in the incandescent lamps, on a par with those that have from time to time taken place in gas burners. When the incandescent lamp was first invented it required 5 watts to 6 watts for one candle of light. Now it requires, according to the size of lamp, 3 watts to 4½ watts for one candle of light. When the manufacture of incandescent lamps in this country is thrown open, and by various improvements in the filament less electrical energy is required to produce each candle of light, the comparison between electrical energy and gas as illuminants will become more and more favourable to electricity. If for the same amount of light a consumer should only use 100 units at 6d. per unit where he now uses 200, electricity to him will practically only cost half its present price.

Again, in the production of electricity at present there are no by-products, but there is a large margin for the utilisation of the electrical plant for purposes other than lighting. The work of generating electricity for lighting is only equivalent to about two and a half hours' use of the plant daily all the year round. If a full use for the plant during the remainder 21½ hours of the 24 were discovered, it would be possible to make a profit out of selling electricity at even less than 2d. per unit. This would correspond, say, to less than 1s. per 1,000ft. for gas. The advantages which gas derives from by-products will probably accrue to electricity in time through by-uses of the plant. However small, therefore, be the margin of profit at the beginning, there is a probability of large profits being made by degrees, without adding to or altering the plant.

To sum up, it may be contended that electricity supply is based at the present stage on sound commercial lines, and that its future is all in the direction of cheaper costs. The question, then, for a local authority to decide is whether it should keep the business in its own hands or sanction its being conducted by a company. If the latter course be adopted, the Electric Lighting Acts provide for a 42 years' tenure by the company. If an arrangement be made for an earlier purchase, it is manifest that the local authority will be called upon to pay a pretty heavy bonus. This, in the case of Leeds, it has been seen, was fixed at about 66 per cent., and in the more recent case of Reading it has been fixed at 33 per cent. It is, however, in any case manifest that the consumers are better off if supplied by the local authority than by a company, because the price charged by a company must cover the cost of administration by directors and also a provision of a good dividend to shareholders, whereas in the case of supply by a local authority there are no directors to pay and no fat dividends to provide. The local authority will easily be able to borrow the capital necessary at 3 per cent. to 3½ per cent., a rate that would hardly satisfy the shareholders in a company. The time at disposal does not permit one to go further into details, but the majority present will, it is hoped, be inclined to admit that a strong case both from the municipal and commercial point of view has been made out for the general establishment of municipal electricity works.

THE

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CONTENTS.

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TRACTION v. TALK.

Last week we commented in these pages upon the position of the National Telephone Company, drawing attention incidentally to the very considerable effect which would doubtless be felt in the telephone industry as a consequence of the then forthcoming report from the Joint Parliamentary Committee on Electric Powers (Protective Clauses). Since then the report itself has appeared, printed in plain black ink on plain white foolscap paper, published at the modest price of one penny, and weighing "under one ounce." There were no fireworks at Westminster when it was first issued; nor, *per contra*, could one hear the doleful strains of a Dead March in "Saul" within the purlieus of Oxford-court. And yet this business-like document will have an effect upon the electrical and allied trades generally throughout this country, to which no amount of engrossed or illuminated parchment addresses in gold and jewelled caskets could ever aspire.

In the first place, it opens up the way at once to more rapid and more reasonable developments in traction methods along our streets and roads than has hitherto been possible; and in the second, it practically compels the telephone service, wherever disturbances arise from an electric tramway, to rearrange its systems within two years on a plan which is confessedly the only one that gives complete satisfaction, which ought to have been adopted at the outset, and which is even now at certain points in process of reluctant installation at the instance of outraged and long-suffering subscribers.

"The undertakers shall, in the use of electric power under the provisions of this Act (order), employ either insulated returns or uninsulated metallic returns of low resistance." With a proviso as to lines where accumulator traction is employed, thus runs Section 1 of the model clause which the joint committee has drawn up. This is the essence of the whole matter, and one may well imagine those interested in the development of electric lines—when reading the apparently stern command "you shall employ," etc., etc.—feeling very much like the youths at a certain school where some amount of pardonable surprise was evoked by a notice to the effect that "Any boy found *outside* Mr. So-and-So's orchard will be severely punished." For electric traction purposes no further powers than those given by the clause would be necessary or desirable; uninsulated metallic returns of low resistance are practically in use to-day upon the majority of successful electric lines, and the result of the committee's investigation is therefore to confirm the employment of such, particularly in the case of overhead conductor systems. It is obviously to the best interests of an electric line that any metallic return should be of low resistance, but by emphasising this point the committee has done well, since it thereby ensures not only that the work of bonding a road for the return circuit shall be properly carried out in the first instance, but also that it shall be carefully maintained afterwards in good condition. Let it be said incidentally that the expression thus used—"bonding a road"—refers wholly and solely to the metallic return circuit: as

a rule, an electric tramway is more likely to prove a success when the bonding is not of a financial character.

Throughout the report there is a marked absence of special stress upon telephonic disturbances due to the use of electric power on tramways, although the enquiry which led to the appointment of this committee arose in no small degree from the readiness of the telephone company to have the matter settled once for all. It would therefore be a little discourteous to enlarge upon the snub direct thus given to the telephone interests; but one cannot help regretting the Tramway Orders or Acts already obtained on conditions wholly unfavourable to the use of the best electrical systems, and the only pity to be felt with regard to the model clause now settled is that it cannot be made retrospective.

Tacked on to the six sections of the clause are some resolutions or recommendations — ten in number—which have been adopted unanimously by the committee; these do not call for special discussion, except that the last one is not so clear as might be wished. We can hardly believe that the committee intended all developments in electric traction to be absolutely postponed for two years from now, and that all future enterprises will require at least that space of time to ripen wherever telephonic disturbance is likely to ensue, although the expressions used are capable of bearing that interpretation. Doubtless the meaning is that after two years have elapsed from the passing of a Tramway Act or order, the telephone company will have no *locus standi* whatever against those using electric power on the tramway with a consequent telephonic disturbance. For working the lines meantime an amicable arrangement between conflicting interests must apparently be entered into.

The whole case of "traction *v.* talk" may be summed up in the epigrammatic language of the "bard of Teddington"—viz., our streets and roads are for travel—not for talk; and this view has been upheld by the committee. The electrical interests may feel devoutly grateful that the matter is thus settled; even the telephone company—if only it knew what was best for itself—would appreciate the result. Would it not, however, be more than curious if in time to come the tramway companies should be found to occupy the position lately held by the telephone interests, on the score of interference with their circuits? Yet he would prove a rash man who could positively assert that no future electrical system might arise to disturb electric lines employing uninsulated metallic returns even of low resistance.

It is, perhaps, invidious to mention any names in chronicling a step forward of such a nature as this report. The advantages which it will develop are due to the hearty goodwill and energetic labours of many, but in common justice we put upon record, as having proved a mainstay of the agitation to get this matter settled with justice, the late Electric Traction Association and its secretary (Mr. Stephen Sellon). So long as the traction interests are looked after with a similar amount of care and foresight, we shall have no fear as to their speedy progress and prosperity.

MUNICIPAL ELECTRICITY WORKS.

This is the title of a paper read by Mr. R. Hammond before the annual meeting of the Municipal Engineers last week. The paper is given elsewhere, and is, as will be seen, mainly historical and statistical. Mr. Hammond is doing good work in pressing electrical matters to the notice of municipalities, but he would do better to leave out of consideration personal questions, such as the bracketed phrase relating to Brighton. It is a tactical blunder, especially in such a paper as this, read ostensibly to induce local authorities to take up the question themselves in face of all comers. Mr. Hammond would have added to the value of his paper if he had tabulated the losses from company work. From October, 1878, to December, 1882, fifty-six companies were floated, with a capital of £20,910,500. Assume that in the following ten years a similar amount of capital had been asked for by companies, giving a total, say, of £40,000,000. How much of this capital was subscribed, and how much is lost, and who has lost it? To tell the truth on these questions might be startling, if not libellous. If we are generous at the expense of truth, we may say that the loss was the cost by which private companies proved the success of the new illuminant. On the other hand, if we are truthful, we shall say that the majority of all the companies floated have been floated to put money into the pockets of promoters, and with very little idea of their being commercially successful. Fortunately, a few have been promoted on true business principles, and with a view to commercial success rather than to promotion-money. However we look at supply by companies, we must acknowledge that in the aggregate too much money leaks from useful works into financiers' pockets. It is not so with municipalities. They may be extravagant; their work may be wastefully done, but the financier is out of it. Hence, if from no other point of view, the "man in the street," who is unbiassed towards companies or municipalities, would at once vote for municipal action, because then the money obtained would at any rate be used in productive work. Ordinarily, the real cost of a central station to a company will be from 25 to 50 per cent. dearer than the cost to a municipality; and further, the latter can get its money from 20 to 40 per cent. cheaper. We are glad, therefore, to find from the statistics of Mr. Hammond that supply companies are dwindling and municipal authorities are increasing.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ACCUMULATOR TRACTION.

SIR,—I am very desirous of obtaining such information from Mr. Brockmam as will leave no doubt in my mind as to the superiority of accumulators over any other form of traction, and as Mr. Broekman has been good enough to

say he will be pleased to submit to me any such information, I should be glad if he would first state specifically what he meant when he said in his letter to you of the 28th ult. that "*The service of the line on which our accumulators are in use is to our knowledge more regular and reliable than that of any line operated on the overhead wire or conduit system,*" and from what source he has obtained this information.

Secondly, will he kindly prove by figures—which I presume he must have in his possession, when he also makes the statement—that "*It can be proved that such a line* (*i.e.*, a line worked by accumulators) *can be more economically worked than any direct-current system?*" On his supplying me with any figures of absolute working as to the total expenses per car mile for motive power, I shall then be pleased to supply him with practical figures of the present cost of working on the overhead system. Will he also give me the price per car mile at which he is prepared to guarantee for a term of years the working of the Bristol-road section of the Birmingham Central Tramways? I mentioned in my letter of the 4th inst. that I looked forward with much interest to the publication of the Birmingham Central Tramways Company's balance-sheet, to see how it bears out the alleged economy of the accumulator system, which means, in plain English: what are the expenses at the generating station, and what is the cost (over 1½d. per car mile which the Epstein Accumulator Company are at present charging for the repairs of their accumulators) of motive power per car mile?

Mr. Brookman states that this will be no criterion, because they have no power to interfere with this expenditure. If this is the case, will Mr. Brookman be good enough to furnish for my information what is the cost at present for this work (which he can obtain by the company's balance-sheet), and in what way and how much he can reduce this amount?

I am perfectly willing to accede to the Epstein Accumulator Company all that they are fairly and honestly entitled to claim, but as a practical man I require a little more information than they have at present provided before I am convinced.—Yours, etc.,
STEPHEN SELLON.

London, S.W., July 17.

INFLUENCE OF CURRENTS ON VOLTMETERS.

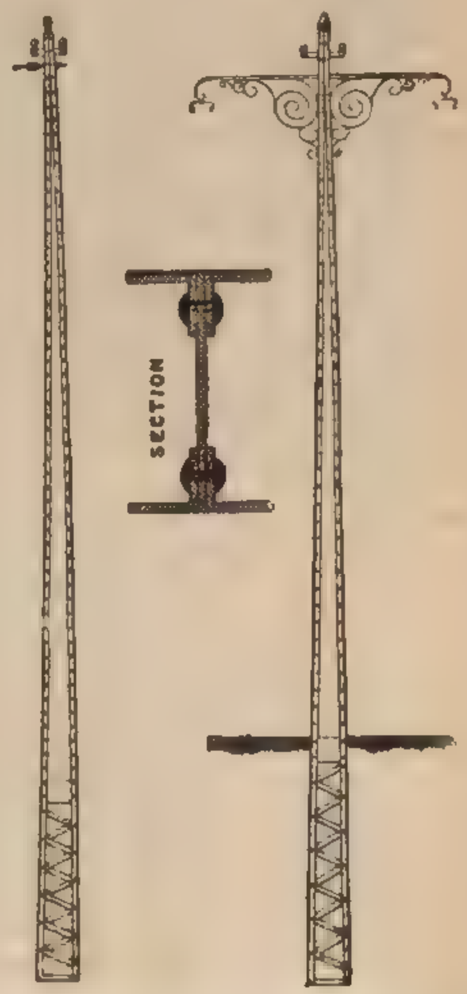
Voltmeters may measure accurately enough when free from stray influences, but if, like some instruments, there are errors of 20 to 50 per cent. near a conductor carrying a current, their value as accurate measuring instruments is lost. We have not seen any special tests given by makers of this nature until recently, when Messrs. Paterson and Cooper, in sending us their new catalogue of measuring instruments, also send the following statement of tests. These tests were made on their dead-beat electromagnet voltmeter to ascertain the error due to large currents in its proximity. They give diagrams showing the position of the instrument relative to the main carrying a very large current, and the error due to this influence at various distances.

Position.	Distance between instrument and main.	Current in main, in amperes.	Error in voltmeter.
Voltmeter placed upon main, main vertical.	Touching.	1,700	6 per cent.
	Raised 2in.	,,	[illegible] ,,
	,, 8in.	,,	[illegible] ,,
	,, 12in.	,,	0 ,,
Ditto, main horizontal.	Touching.	1,700	2 ,,
	Raised 2in.	,,	1½ ,,
	,, 5in.	,,	0 ,,
Voltmeter alongside main, main vertical.	Touching.	1,700	½ ,,
Ditto, main horizontal.	Touching.	1,700	¾ ,,
	1½in. away.	,,	½ ,,

From the above it will be seen that these instruments are practically unaffected by currents in their neighbourhood, unless placed directly over the leads, as in the first and second position.

TROLLEY WIRE POLES.

The decision of the Joint Parliamentary Committee on the traction *v.* telephone dispute is considered by all those who are qualified to speak upon the subject from an intimate knowledge of its full bearing to imply a rapid and immediate advance in the development of electric lines operated on the overhead conductor system, and until a better or cheaper method of working tramways can be devised, it seems useless for obstacles to be set up against the general adoption of this system simply on the score of its æsthetic disadvantages.



On suburban roads where tramcars perhaps already run, there can be no serious grounds whatever for opposing the introduction of an electric system, even on the overhead conductor principle, and but a very few years will pass before we shall see in almost every populous district in this country much greater facilities for cheap and rapid transit owing to the adoption of electricity as the motive power.

In view, therefore, of the undoubted early developments in this art, there will be many firms whose interests are directly affected thereby in a most beneficial degree. Amongst such we may classify those engaged in the manufacture or supply of iron and steel appliances required for

working an overhead conductor electric tramway. At present there seem to be very few indeed who have endeavoured to lay themselves out for this and similar work, with the idea of making it a speciality. The firms engaged in the manufacture of electric railway equipment—apart from strictly electrical appliances—are as yet quite in the background.

So far as the metal poles for trolley wires are concerned, these can be obtained even now from a few of the leading firms—such as the Messrs. Russells, Mr Joseph Aird, Messrs. Dick, Kerr, and Co., Messrs. J. Menzies and Co., and others; but there must be plenty of makers who might find sources of profit in a speciality, and in order to introduce such to their notice, as well as show what is being done elsewhere, a brief description is annexed, with illustrative engravings representing a steel trolley wire pole or standard which is put on the American market by the Berlin Iron Bridge Company, of East Berlin, Connecticut

It will be seen from the illustrations that this arrangement of standard is built up of a steel plate narrowed down throughout its length, and riveted on the edges to four angle irons, two on each side. The double ribs thus formed will undoubtedly give considerable strength where it is most needed—i.e., in opposition to the side pull—indeed, the makers claim especially for this type of standard that the strains can be determined beforehand very exactly, and the proper proportion of metal thereby employed.

An allowance of 6ft. in length is made for insertion in the ground, the base being opened out, as shown, into a lattice-work arrangement, so as to ensure a thorough bedding into the cement or concrete foundation.

Together with this pole the makers also supply a special type of span-wire insulator holder. This consists of a long screwed rod, with lock nuts for adjusting the strain, and a neat form of hood or covering, which is claimed to act perfectly as a protection against the formation of sleet or frozen snow on the insulator, whereby leakage might possibly ensue.

Without going so far as to admit any great superiority in these devices over such, for instance, as are employed on the South Staffordshire line, one cannot remember too often that even the best things are not perfect, and that much may be learnt from studying very carefully all possible types of appliances, quite irrespective of the commercial value which they may have in the English market.

ON LIGHT AND OTHER HIGH-FREQUENCY PHENOMENA.*

BY NIKOLA TESLA.

(Continued from page 19).

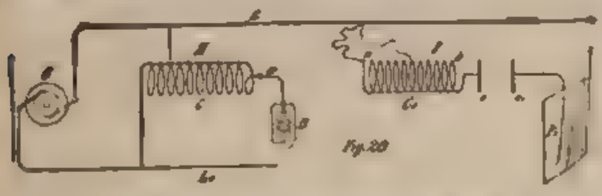
ON ELECTRICAL RESONANCE.

The effects of resonance are being more and more noted by engineers and are becoming of great importance in the practical operation of apparatus of all kinds with alternating currents. A few general remarks may therefore be made concerning these effects. It is clear that if we succeed in employing the effects of resonance practically in the operation of electric devices the return wire will, as a matter of course, become unnecessary, for the electric vibration may be conveyed with one wire just as well, and sometimes even better, than with two. The question first to answer is, then, whether pure resonance effects are producible. Theory and experiment both show that such is impossible in Nature, for as the oscillation becomes more and more vigorous the losses in the vibrating bodies and environing media rapidly increase and necessarily check the vibration which otherwise would go on increasing for ever. It is a fortunate circumstance that pure resonance is not producible, for if it were there is no telling what dangers might not lay in wait for the innocent experimenter. But to a certain degree resonance is producible, the magnitude of the effects being limited by the imperfect conductivity and imperfect elasticity of the media or, generally stated, by frictional losses. The smaller these losses, the more striking are the effects. The same is the case in mechanical vibration. A stout steel bar may be set in vibration by drops of water falling upon it at proper intervals; and with glass, which is more perfectly elastic, the resonance effect is still more remarkable, for a goblet may be burst by singing into it a note of the proper pitch. The electrical resonance is the more perfectly attained, the smaller the resistance or the impedance of the conducting path and the more perfect the dielectric. In a Leyden jar discharging through a short stranded cable of thin wires these requirements are probably best fulfilled, and the resonance effects are therefore very prominent. Such is not the case with dynamo machines, transformers and their circuits, or with commercial apparatus in general in which the presence of iron cores complicates or renders impossible the action. In regard to Leyden jars with which resonance effects are frequently demonstrated, I would say that the effects observed are often attributed but are seldom due to true resonance, for an error is quite easily made in this respect. This may be undoubtedly demonstrated by the following experiment. Take, for instance, two large insulated metallic plates or spheres which I shall designate A and B, place them at a certain small distance apart and charge them from a frictional or influence machine to a potential so high that just a slight increase of the difference of potential between them will cause the small air or insulating space to break down. This is easily reached by making a few preliminary trials. If now another plate fastened on an insulating handle and connected by a wire to one of the terminals of a high tension secondary of an induction coil, which is maintained in action by an alternator (preferably high frequency)—is approached to one of the charged bodies, A or B, so as to be nearer to either one of them, the discharge will invariably occur between them; at least, it will if the potential of the coil in connection with the plate is sufficiently high. But the explanation of this will soon be found in the fact that the approached plate acts inductively upon the bodies A and B, and causes a spark to pass between them. When this spark occurs, the charges which were previously imparted to these bodies from the influence machine must needs be lost, since the bodies are brought in electrical connection through the arc formed. Now this arc is formed whether there be resonance or not. But even if the spark would not be produced, still there is an alternating E.M.F. set up between the bodies when the plate is brought near one of them; therefore the approach of the plate, if it does not always actually, will, at any rate, tend to break down the air space by inductive action. Instead of the spheres or plates, A and B, we may take the coatings of a Leyden jar with the same result, and in place of the machine, which is a high frequency alternator preferably, because it is more suitable for the experiment, and also for the argument, we may take another Leyden jar or battery of jars. When such jars are discharging through a circuit of low resistance the same is traversed by currents of very high frequency. The plate may now be connected to one of the coatings of the second jar, and when it is brought near to the first jar just previously charged to a high potential from an influence machine, the result is the same as before, and the first jar will discharge through a small air space upon the second being caused to discharge. But both jars and their circuits need not be tuned any closer than a basso profundo is to the note produced by a mosquito, as small sparks will be produced through the air space, or at least the latter will be considerable more strained owing to the setting up of an alternating E.M.F. by induction, which takes place when one of the jars begins to discharge. Again, another error of a similar nature is quite easily made. If the circuits of the two jars are run parallel and close together, and the experiment has been performed of discharging one by the other, and now a coil of wire be added to one of the circuits whereupon the experiment does not succeed, the conclusion that this is due to the fact that the circuits are now not tuned, would be far from being safe. For the two circuits act as condenser coatings and the addition of the coil to one of them is equivalent to bridging them, at the point where the coil is placed, by a small condenser, and the effect of the latter might be to prevent the spark from jumping through the discharge space by diminishing the alternating E.M.F. acting across the same. All these remarks, and many more which might be added but for fear of wandering too far from the subject, are made with the pardonable intention of cautioning the unsuspecting student, who might gain an entirely unwarranted opinion of his skill when seeing every experiment succeed, but they are in no way thrust upon the experienced as novel observations.

In order to make reliable observations of electric resonance effects it is very desirable, if not necessary, to employ an alternator giving currents which rise and fall harmonically, as in working with make and break currents the observations are not always trustworthy, since many phenomena which depend on the rate of change may be produced with frequencies widely different. Even when making such observations with an alternator one is apt to be mistaken. When a circuit is connected to an alternator there are an infinite number of values for capacity and self-induction which, in conjunction, will satisfy the condition of resonance. So there are in mechanics an infinite number of tuning forks which will respond to a note of a certain pitch, or loaded springs which have a definite period of vibration. But the resonance will be most perfectly attained in that case in which the motion is effected with the greatest freedom. Now in mechanics, considering the vibration in the common medium—that is, air—it is of comparatively little importance whether one tuning fork be somewhat larger than another, because the losses in the air are not very considerable. One may, of course, enclose a tuning-fork in an exhausted vessel and by thus reducing the air resistance to a minimum obtain better resonant action. Still the difference would not be very great. But it would make a great difference if the tuning fork were immersed in mercury. In the electrical vibration it is of enormous importance to arrange the conditions so that the vibration is effected with the greatest freedom. The magnitude of the resonance effect depends, under otherwise equal conditions, on the quantity of electricity set in motion or on the strength of the current driven through the circuit. But the circuit opposes the passage of the currents by reason of its impedance, and therefore to secure the best action it is necessary to reduce

* A lecture delivered before the Franklin Institute, at Philadelphia, February 24, 1893; and, before the National Electric Light Association, at St. Louis, Mo., March 1, 1893.

the impedance to a minimum. It is impossible to overcome it entirely, but merely in part for ohmic resistance cannot be overcome. But when the frequency of the impulses is very great, the flow of the current is practically determined by self induction. Now self induction can be overcome by combining it with capacity. If the relation between these is such that at the frequency used they annul each other that is, have such values as to satisfy the condition of resonance and the greatest quantity of electricity is made to flow through the external circuit then the best result is obtained. It is simpler and safer to join the condenser in series with the self induction. It is clear that in such combinations there will be, for a given frequency, and considering only the fundamental vibration, values which will give the best result with the condenser in shunt to the self induction coil; of course more such values than with the condenser in series. But practical conditions determine the selection In the latter case in performing the experiments one may take a small self induction and a large capacity or a small capacity and a large self induction, but the latter is preferable, because it is inconvenient to adjust a large capacity by small steps. By taking a coil with a very large self induction the critical capacity is reduced to a very small value, and the capacity of the coil itself may be sufficient. It is easy, especially by observing certain artifices, to wind a coil through which the impedance will be reduced to the value of the ohmic resistance only and for any coil there is, of course a frequency at which the maximum current will be made to pass through the coil. The observation of the relation between self induction, capacity, and frequency is becoming important in the operation of alternate current apparatus, such as transformers or motors, because by a judicious determination of the elements the employment of an expensive condenser becomes unnecessary. Thus it is possible to pass through the coils of an alternating current motor under the normal working conditions the required current with a low E.M.F., and do away entirely with the false current, and the larger the motor the easier such a plan becomes practicable; but it is necessary for this to employ currents of very high potential or high frequency.



Plan followed in Observing the Effects of Resonance.

In Fig. 20 I. is shown a plan which has been followed in the study of the resonance effects by means of a high frequency alternator. C is a coil of many turns, which is divided in small separate sections for the purposes of adjustment The final adjustment was made sometimes with a few thin iron wires (though this is not always advisable), or with a closed secondary. The coil, C is connected with one of its ends to the line, L, from the alternator, G, and with the other end to one of the plates, c, of a condenser, $c\,c_1$, the plate, c_1, of the latter being connected to a much larger plate, P_1. In this manner both capacity and self induction were adjusted to suit the dynamo frequency.

(To be continued.)

BOROUGH OF BOLTON.

The following are the regulations in connection with the supply of electricity to houses and other premises:

Application for Supply.—Persons requiring a supply of electricity must fill up and sign an application form, giving particulars as to the number and power of lamps proposed to be fixed, and approximately the maximum number likely to be in use at any one time. Also particulars of any other intended use of the current. Forms of application may be obtained at the office of the borough electrical engineer, and should be returned to him, duly filled up, at least 14 days before the supply is required

Character of Supply.—The Corporation will supply an alternating current of about 5,500 complete periods or alternations per minute, and at a mean pressure of 100 volts at the main cut out box.

Three Wire System.—The Corporation reserves to itself the right of supplying any building containing more than 150 lamps of 16 c.p. (or their equivalent), or requiring a large and varied amount of current, at a mean pressure of 200 volts at the main cut-out box, the circuits being subdivided to 100 volts each on the three-wire system. In any case such a building must be wired in at least two entirely distinct circuits, and these should be so arranged that as equal a demand as possible will take place on each.

Wiring.—The whole of the internal wiring and fittings should be carried out by a responsible firm, and must be in accordance with the current rules of the Phœnix Fire Office, and of any other regulations which the Corporation may require

Conductors.—No conductors used shall carry a current greater than 1,000 amperes per square inch of their cross section, and the size of the conductors must be so proportioned that the fall of pressure between the main cut-out box and the farthest lamp shall not exceed 2 per cent. when the maximum number of lamps are on. All conductors to be highly insulated with pure and vulcanised indiarubber, braid and compound, to give a minimum insulation resistance of 300 megohms per mile Lead covered cables are not to be used unless concentric, and in any case not without the special permission in writing of the borough electrical engineer Where metal tubes are used as a protection, both conductors must be placed together in the same tube, which should be of sufficient size to prevent damage in drawing in or out. Under no circumstances whatever are staples or metal saddles to be used to fasten down conductors

Samples.—The Corporation, through their electrical engineer, may require samples of the various wires and cables proposed to be used, with a statement of the maximum current to be sent through each.

Arc Lamps.—When arc lamps are used they should be specially made to burn with alternating currents of the stated periodicity, and a choking coil must be used in each circuit instead of a resistance. The type of arc lamp, choking coil, etc., must be approved by the borough electrical engineer before being used.

Motors and other Apparatus.—Any apparatus not used for ordinary lighting purposes such as motors, regulating switches, resistances, choking coils, heating appliances, etc.—must be approved by the borough electrical engineer before being used.

Gas Fittings.—Gas fittings must not be used for the support of electrical lamps or wires, unless the gas supply is entirely cut off and the fittings are thoroughly insulated from "earth." Special permission, however, may be given for a modification of this rule under certain circumstances.

Main Cut-out Box and Meter.—The Corporation will supply and fix a main cut-out box, and bring their service mains to it free of charge when the distance from the nearest distributing mains does not exceed 60ft. The house mains must be brought to the cut-out box by the consumer, but connection thereto is only to be made by the Corporation officials. Sufficient cable must be left for the meter connection The Corporation will supply meters at fixed rentals, and reserves to itself the right of deciding upon the positions of all meters. When the householder has made proper application for the supply of current, the borough electrical engineer, or his representative, will, if desired, point out the position to be occupied by the main cut out box and meter.

Main Switch.—A double pole switch must be fixed by the consumer in each circuit of the house mains, and on the consumer's side of the meter. Such switches to be securely protected, and to be of a type approved by the borough electrical engineer.

Testing.—No building will be supplied with current until the wiring has been tested and passed by the borough electrical engineer. One test will be made free of charge. At least 24 hours' notice must be given, in writing, to the engineer before a test can be made, and the engineer will then appoint a time. The contractor's representative should be present at the time appointed. The whole work must be completed with fuses in and lamps fixed before a test can be made. If the work be not ready for testing, or should it fail to pass test, a fee of 10s. 6d. must be paid at the office of the electrical engineer before any further test can be made. To avoid misunderstandings with their clients, contractors are advised to test the work themselves before giving notice to the Corporation

Refusal to Supply.—The Corporation may refuse to supply current to any building if (1) the work be not carried out in accordance with these regulations; (2) the whole of the work be not completed, and the fittings permanently fixed; (3) when tested with a continuous current of 100 volts pressure, the insulation resistance of any circuit falls below the following—viz.,

$$\text{Insulation resistance in ohms} = \frac{15,000\,000}{\text{Max. current in amperes}}.$$

This applies to the insulation resistance measured either between the circuit and "earth," or between the circuit and any other circuit.

Leakage.—The Corporation reserves to itself the right at any time, and if necessary without notice, to cut off the supply to the whole or any part of the building, if the insulation becomes defective, or the work otherwise unsafe.

Additional Lights.—If alterations to the wiring, or additional lamps be contemplated, notice must be given in writing to the borough electrical engineer, and such additional work must be tested and passed by him before current is supplied to the altered or new circuits. Non-compliance with this rule will render the whole supply liable to be cut off

Access for Inspection.—Free access must be allowed to the premises at all reasonable times to the proper officers of the Corporation to examine, test, or inspect in any way they may deem necessary, the wiring, fittings meters, and all other matters connected with the electric supply, and all reasonable and suitable facilities must be afforded by the consumer to the officers of the Corporation to enable them to do so.

General Conditions.

The supply of electricity will be subject to the regulations issued from time to time by the Bolton Corporation and authorised by the Bolton Electric Lighting Order, 1891

Current will be charged at the following rates per Board of Trade unit viz. For any consumption above 12½ B.T. units, per 16 c.p. lamp (or equivalent) fixed, per quarter 5½d. per B.T. unit; between 10 and 12½ units, 6d. per unit; between 7½ and 10 units, 6½d. per unit, between 5 and 7½ units, 7d. per unit; between 2½ and 5 units 7½d. per unit, below 2½ units, 8d. per unit.

One B.T. unit is equal to 1,000 watts consumed in one hour. A 16 c.p. incandescent lamp requires 60 watts (approx.), and will thus consume one B.T. unit in $\frac{1000}{60}$ = about 16⅔ hours

Examples.—A customer having 20 16 c.p. incandescent lamps fixed, and using 220 B.T. units per quarter, would be charged at

the rate of 6d per B.T. unit. A customer having four arc lamps fixed, each taking 600 watts (or equivalent to 10 16 c p incandescent lamps each), and using 650 B T. units per quarter, would be charged at the rate of 5½d per B T unit.

Meters will be charged for at the following rentals viz., for 15 16 c p. lamps or their equivalent, 2s. per quarter; for 40 ditto, 2s. 9d per quarter; for 80 ditto, 3s 3d per quarter; for 160 ditto, 4s. per quarter A discount of 2½ per cent will be allowed on all accounts paid within 21 days of the date thereof.

Application Form for Supply of Electricity

BOLTON CORPORATION ELECTRICITY SUPPLY.
Bolton Electric Lighting Order, 1891

To the Bolton Corporation —Please supply electricity to the undermentioned premises and for the following purposes—viz.:

Incandescent Lamps.

Candle power	8	16	32	50
Number fixed				
Maximum number at one time.				

Arc Lamps.

Number fixed			
Current in amperes			
Singly or in pairs			

Note.—Arc lamps may be burned in pairs from the supply mains. If single lamps are joined direct to the mains it must be so stated.

Other Purposes.

Class of apparatus			
Number fixed			
Current in amperes.			

Name of wiring contractor
Signed
Address
Premises to be supplied
Date 18

REPORT OF JOINT COMMITTEE ON ELECTRIC POWERS (PROTECTIVE CLAUSES).

The committee have taken evidence from Sir Courtenay Boyle, K C B, from Mr. Preece, engineer in chief and electrician to the Post Office, from Major Cardew, electrical adviser to the Board of Trade, and the Astronomer Royal. Counsel appeared before them on behalf of: 1. The National Telephone Company 2. The railway companies. 3. Electric tramway companies, and electric underground railway companies. 4 Electric lighting companies. 5. Municipal corporations, England and Scotland. 6. Tramway Institute of Great Britain and Ireland. 7. Gas and water companies. Her Majesty's Postmaster General was also represented but not by counsel.

The committee have heard all the witnesses tendered by the several parties, and have agreed upon the following clause, to be inserted in all Bills and provisional orders which authorise the undertakers, other than electric lighting undertakers, to use large electric currents—viz.:

Clause to be inserted in all Bills and provisional orders which authorise any company, corporation, or person, collectively referred to as "the undertakers," to use larger electric currents for other than electric lighting purposes. (Some modifications of form may be required to meet the circumstances of particular cases.)

(1) The undertakers shall, in the use of electric power under the provisions of this Act (order) employ either insulated returns or uninsulated metallic returns of low resistance (This clause not to apply in the case of railways, tramways, or tram roads in which the motive power is entirely self contained.)

(2) The undertakers shall take all reasonable precautions in constructing, placing and maintaining their electric lines and circuits, and other works of all descriptions, and also in working their undertaking so as not injuriously to affect, by fusion or electrolytic action, any gas or water pipes, or other metallic pipes, structures, or substances.

(3) The exercise of the powers by this Act (order) conferred with respect to the use of electric power shall be subject to the regulations set forth in the schedule to this Act (order), and to any regulations which may be added thereto or substituted therefor, respectively, by any order which the Board of Trade may, and which they are hereby empowered to make from time to time, as or when they may think fit, for regulating the employment of insulated returns or of uninsulated metallic returns of low resistance, for preventing fusion or injurious electrolytic action of or on gas or water pipes, or other metallic pipes, structures, or substances, and for minimising, as far as is reasonably practicable, injurious interference with the electric wires, lines, and apparatus of other parties and the currents therein, whether such lines do or do not use the earth as a return.

(4) The undertakers using electric power contrary to the provisions of this Act (order), or to any of the regulations set forth in the schedule to this Act (order), or to any regulation added thereto or substituted therefor by any order made by the Board of Trade under the authority of this Act (order), shall, for every such offence, be subject to a penalty not exceeding £10, and also in the case of a continuing offence to a further penalty not exceeding £5 for every day during which such offence continues after conviction thereof. Provided always that, whether any such penalty has been recovered or not, the Board of Trade, in case in their opinion the undertakers in the use of electric power under the authority of this Act (order) have made default in complying with the provisions of this Act (order), or with any of the regulations set forth in the schedule to this Act (order), or with any regulation which may have been added thereto or substituted therefor as aforesaid, may by order direct the undertakers to cease to use electric power, and thereupon the undertakers shall cease to use electric power, and shall not again use the same, unless with the authority of the Board of Trade, and in every such case the Board of Trade shall make a special report to Parliament notifying the making of such order.

(5) The undertakers shall take all reasonable and proper precautions in constructing, placing, and maintaining their electric lines, circuits, and other works of any description, and in using their electric lines, circuits, and other works, so as not injuriously to interfere with the working of any wire, line, or apparatus, from time to time used for the purpose of transmitting electric power, or of telegraphic, telephonic, or electric signalling communication, or the currents in such wire, line, or apparatus: Provided always that the undertakers shall be deemed to take all such reasonable and proper precautions as aforesaid, if and so long as they adopt and employ at the option of the undertakers, either such insulated returns or such uninsulated metallic returns of low resistance, and such other means of preventing injurious interference with the electric wires, lines, and apparatus of other parties, and the currents therein, as the Board of Trade shall direct, and in giving such directions the Board shall have regard to the expense involved, and to the effect thereof upon the commercial prospects of the undertaking. Provided also that at the expiration of —— years from the passing of this Act (order), nothing in this sub section shall operate to give any right of action in respect of or to protect any electric wires, lines, or apparatus, or the currents therein, unless in the construction, erection, maintaining, and working of such wires, lines, and apparatus, all reasonable and proper precautions, including the use of an insulated return, have been taken to prevent injurious interference therewith, and with the currents therein, by or from other electric currents. If any difference arises between the undertakers and any other party with respect to anything in this sub section contained, such difference shall, unless the parties otherwise agree, be determined by the Board of Trade, or at the option of the Board by an arbitrator to be appointed by the Board; and the costs of such determination shall be in the discretion of the Board, or of the arbitrator, as the case may be.

(6) Nothing in this section shall apply to the use of any electric line, circuit, or work of any company, corporation, or person authorised by Act of Parliament, or provisional order confirmed by Parliament, to supply energy for electric lighting purposes, so far as such use is limited to such purposes.

The committee have also agreed upon the following resolutions in the nature of recommendations—viz.:

(1) The committee having regard to the evidence before them, are of opinion that it is not in the present state of electrical science to the interest of the public to insist upon electrical tramways using an insulated return conductor, and that such insistance would retard the development of electric traction.

(2) The chief objections which have been urged before the committee to an uninsulated return conductor are, first, the interference by leakage and induction with telephones; secondly, the interference by leakage and induction with railway signals; thirdly, the damage to systems of gas and water pipes by the action of leakage currents.

(3) They are of opinion that the best known means of overcoming the first of these disturbances is by providing an insulated return conductor for the telephones, and they have the less hesitation in recommending this course as the evidence shows that telephone construction is already tending in this direction, and that better results are secured to the public by the use of a twisted metallic circuit insulated entirely from the earth.

(4) The second objection deserves serious consideration on account of the danger to the public, but the committee are of opinion that the disturbance may be remedied at comparatively small expense by the adoption of an insulated metallic return by the railway companies.

(5) They consider that, although electric tramway and electric railway companies should be allowed to use the wheels of carriages and the rails to complete the electric circuit, the currents should be produced and used in such a manner as to mitigate as far as is practicable any injurious effect to telephonic communication.

(6) The committee are of opinion that it is desirable in every way to facilitate the use of complete insulated metallic circuits for telephones, and for this end they recommend that statutory powers be granted enabling telephone undertakers to lay their wires underground.

(7) The danger from fusion or electrolytic action appears to the committee to have arisen from a faulty system of constructing

electric tramways, and they are of opinion that it can be reduced by improved methods of construction so as to be practically negligible.

(8) The committee therefore recommend that the Board of Trade shall, in virtue of the powers to be conferred upon them by each Act or order, make regulations to secure the best system of working electric tramways and railways, having regard to the expense involved by the carrying out of such regulations, and to the effect thereof upon the commercial prospects of the undertaking. The regulations to provide, *inter alia* (a) That a return conductor, if in contact with the ground, shall be of such section and resistance as to have no difference of potential sufficient to set up injurious leakage currents in the earth. (b) That, both with regard to the structure of the line and to the method of generation and use of the electrical current, everything shall be maintained up to the standard required by the Board of Trade; but, if the regulations are altered after the use of electric power on the line has been sanctioned, the undertakers shall not be required to alter the structure or method of working of the line to conform to the more recent regulations, except for the public safety, or unless it shall be proved to the satisfaction of the Board of Trade that any system of metallic pipes or structures is being injured by the action of electricity escaping from the conductors, or for purposes other than public safety or injury to pipes or structures which the Board may think right, provided that the alterations do not in such last case cause substantial additional expenditure. (c) That all such electrical tests shall be applied to the line by the undertakers as the Board of Trade may think necessary, and that a record of these tests shall be kept for the information of the Board of Trade. (d) That the Board of Trade shall have all reasonable facilities for making any tests they may think necessary, in addition to those recorded by the undertakers to enable them to ensure the maintenance of satisfactory conditions.

(9) That the committee regards with apprehension a large extension of the system of overhead wires in crowded centres.

(10) It appears to the committee to be just that undertakers proposing to use large currents should be required to give ample notice to those using small currents to enable them to protect themselves by insulation, and that with this view, and in reference to the clause agreed upon, a period of two years may fairly be allowed to telephone and telegraph companies from the date of the passing of any Act (order).

LEGAL INTELLIGENCE.

BLACKIE v. THE ELECTRICITY SUPPLY CORPORATION.

This was an action before Mr Justice Cave and a special jury, on Friday, brought by a clockmaker and jeweller carrying on business at 392, Strand, for damages and an injunction restraining the defendants from carrying on their business so as to cause a nuisance. The defendants' central station is situated in Bull Inn court, Strand, about 150ft. from the back of the plaintiff's shop. The defendants' machinery consists of 10 engines and dynamos, five of which are of 200 h.p. each. Two engines are in the basement on cement concrete foundations 6ft. thick. The other engines rest upon the floor of the building, constructed of iron girders supporting a bed of concrete 3ft. thick. The floor is supported by iron stanchions resting upon concrete foundations let into the ground 6ft. thick. The defendants at the busiest time of the day work four of the engines and dynamos, producing a current of from 2,000 to 3,000 amperes at a pressure of 100 volts. The engines are not worked up to their full load, but are generally run at about half load, more engines being employed to produce the necessary current. The plaintiff was called in support of his case, and stated that he first felt vibration in his premises in September, 1891, which he attributed to the working of the defendants' engines. The vibration affected his regulator so that he had to send his watches and chronometers to be regulated elsewhere. The housekeeper and his wife were also called and stated that the vibration was considerable during the evening, shaking the windows of the house; that the vibration occurred on July 6, when all traffic was stopped in the Strand. Other witnesses from the neighbourhood were called, and said they had felt vibration which they thought came from the defendants' works. For the defence witnesses were called who had visited the plaintiff's premises, and stated that the vibration was not felt in the house, but only on the roof, which was only appreciable by means of the most sensitive instruments.

Mr. Justice Cave, in summing up said that when a person made use of his land in a way differing from others round about he must take care not to inflict injury or discomfort on others. In this case the defendants clearly were not doing what people all round were doing. The test was, had the defendants done anything which had made the enjoyment of the plaintiff's house uncomfortable, or had they seriously interfered with the plaintiff's carrying on his business? If either had happened, then the plaintiff was entitled to a verdict. If neither had happened, then the defendants were entitled to a verdict. It was said that the defendants had communicated vibration to plaintiff's property. If they had done that so as to substantially interfere with his comfort or his business, then the plaintiff would be entitled to a verdict. The plaintiff had two strings to his bow—first, an alleged interference with his comfort; secondly, an interference with his business—namely, that his regulator was affected, and he had to get his watches regulated elsewhere at considerable cost. It was not easy to make out what damage had been suffered.

The jury found that there was vibration, but that the vibration was so slight that the damages were inappreciable.

The learned **Judge** held that was a verdict for the defendants, and judgment was entered accordingly.

Mr Bousfield, Q.C., Mr Morton Smith, and Mr. Bodilly were for the plaintiff; Mr Moulton, Q.C., Mr English Harrison, and Mr. A. B. Terrell for the defendants.

COMPANIES' MEETINGS.

NATIONAL TELEPHONE COMPANY, LIMITED.

On Tuesday, Mr. J. Staats Forbes (president) occupied the chair at the thirteenth ordinary general meeting of this Company, held at the Cannon street Hotel, E.C. The Secretary (Mr. A. Anns) read the notice convening the assembly, and the report and accounts were taken as read.

The **Chairman**, in moving the adoption of the report and accounts, said it would interest them to learn that the partners in the undertaking numbered 6,721 ordinary and 1,820 debenture holders, or 8,541 in all. The year completed had been one of progress and one of spending money pretty freely. Referring to No. 1 account, they would see how it stood at the end of last year, and he drew attention to one or two points about it, especially as to how it stood now, what the money had been spent upon, how it had been raised, and how it affected the question of net profit, and therefore dividends. They would observe on the debtor side very considerable additions in the purchase of several undertakings. As they knew, the policy of the Directors had been during the past few years to bring into the brotherhood all the subsidiary outside companies. The amalgamation of the three great companies which became the National, had showed them the wisdom of fusion so strongly that they had from time to time induced those other companies which were less important to come in, with the result that now they were practically all absorbed. The Western Counties and South Wales was down for £277,607, the Sheffield Telephone Exchange and Electric Light Company, of which they had bought only the telephone business for £38,696, and some other minor companies, some in being, and some threatening to be in being, but not very important. Those several companies together made up the sum of £345,776, and they had brought in areas not previously within the government of the National Company; but the parent concern—the combination of the companies described as the National Company—they, like the others, were progressing. The subscribers grew, and the peculiarity of the business was that every single new subscriber meant a special outlay for himself. It was somewhat different to some other enterprises, where the original outlay, for whatever purpose, involved a considerable first cost, but when the machine was started its capacity was a very long time being exhausted; but in the telephone business every subscriber could not be connected without money down at first. That money had to be found, and therefore it bore interest some few months in advance of the completion of the work which produced the income. The amounts expended upon construction and other capital charges were £305,799. They would therefore see that a very large sum of money had been spent in the year—£651,575—and that money had had to be provided. It was provided by the issue of certain of their stocks, in ordinary shares and third preference, and in round figures it came to £595,000. Those subscriptions had brought upon the year a certain amount of charge which made its influence felt when they came to the net revenue account. The Directors called attention specially to the large expenditure for the acquisition of the other companies, and they were quite prepared to take the responsibility for having done it. There were some other charges to which he would refer later, but having got into the minds of the proprietors that the Directors had spent a considerable sum of money, that they had had to issue stock to meet it, and that that stock, of course, added considerably to the net revenue account, he would then pass to the results. Money expended in that way was not immediately productive—it took a certain time to develop. However, he did not think they had done badly in the result, because if they turned to the net revenue account they would there see what had taken place. There had been a considerable addition to the Company's business. At the last meeting he had had occasion to impress upon the shareholders the necessity for finding a factor—something which would enable them to measure the way and results. The Directors had tried in this undertaking to find some factor to form a standard of comparison, and the nearest thing was wires, not subscribers. It was true that the mass of the wires served an individual subscriber, but some subscribers used more than one wire, some two or three, but each wire entailed specific expenditure, and the multiplication of wires meant a multiplication of business, and that meant operating, and therefore a wire might be looked upon as an instrument used by individual persons; and it was the nearest thing they could find by analogy to a train mile in railways. Therefore they were to deal with wires. Now the progress of wires was one measure of measuring the progress of business. They had in the year increased from 47,878 wires to 59,031—that meant an advance of 11,153. He must qualify that by reminding them that they had brought in during that period the corpus of the Western Telephone Company, who had, when they took over the company, about 4,000 wires. Deducting that, it showed that the normal progress had not been 11,153, but 7,153. The Directors had the means of testing the cost of putting on a subscriber. If they divided the figure £305,799 for construction

of exchange, trunk and private lines, they would see that the average was something like £42 per subscriber or per wire. Some people had an idea that it could be done for much less, but the Directors knew. They believed in the undertaking and the experience and the skill at their command enabled them to determine exactly the right thing to do and to do it in the most economical and best fashion and it worked out at £42 per wire. Now about the results, for which he would take them to the paragraphs of the report. The income had reached £583,590, which was an increase of £119,848 over the preceding year. He would remind them there that both the Sheffield Company, and especially the Western Company, were included in that amount, and their income which subsisted last year was incorporated bodily in that, and it was not attributed to any abnormal increase of the United Company; but they had contributed a fair proportion to that increase. That increase did not show altogether the advance they had made in the business. The next item was extremely important; it was the rentals carried forward this year, amounting to £285,020, as compared with £234,370, or an increase of £50,649. Their money was paid in advance, and they made contracts from day to day, but taking a year's subscriptions, it was obvious that a portion overlapped a portion of the following year, so that in the year they had received in cash £50,649 more than in the corresponding year for services falling upon the coming year, but that was an increase of income already in their pockets. Now the working expenses followed in all ways the increase of the business; they were very large in proportion to the increase of money—£75,392 out of £119,848. That arose from one or two causes. Like the income of the Western and other companies brought in to swell the gross receipts, the working expenses of those new areas came in to swell the working expenses; and with this disadvantage in comparison, that those areas were more sparsely populated, the income per subscriber was relatively less, and the expenditure relatively more, than in the bigger undertaking. Thus they diluted the averages. They were working at an enhanced percentage of the gross income because they had added the gross income of those companies where the working expenses bore a higher proportion than their own. Then again, of course, the older the institution, the more compact, the more it was developed, and those outlying areas were not quite developed to the extent of the parent districts, but all that was for the future. There was perceptible development. There were certain considerable fixed charges which were not affected by there being 1,000 or 2,000 more subscribers. They did not add any more to the cost of working, and to that extent they kept dropping a portion on those charges. The net result for the year, after deducting Post Office royalties, amounted to £54,220. That was a pretty stiff tax to levy on a company like that. The Company were always being pulled to pieces because they did not reduce the tariff. The reduction of tariff meant that the expense was not diminished. The undertaking, although very sound, and its future might be regarded as assured, yet the difference of a very small reduction might mean a very large effect upon the dividends. If they picked those figures to pieces, they would find that they were not now so far in excess of charge when it was compared with the cost, as to be able to make any great reduction. People somehow who did not know were always ready to dictate what they ought to do. They were not concerned as to whether it was wise or whether it paid to do it. The Company were held up to odium because they were so enormously dear, and contrasts were drawn—New York, Boston, St. Petersburg, Berlin, anywhere where the circumstances were entirely different, so different as to produce a very serious effect upon the profit. First of all, about what they did that they were not progressive. Well, he had some figures that were eloquent. This Company was fused, and their first year's business was in 1890. The average receipt throughout the area served by the Company was £14. 11s. 4d. in 1890; in 1893 the average was reduced to £9. 17s. 9d., and he would venture to say that there was no comparison between that charge and the charge in any other great city in Europe, even including Berlin. In 1890 the proportion of expenses to earnings was 49½ per cent., whilst during the past year it had been 62·9 per cent. The reduction went out of their pockets. The number of lines had increased from 26,086 to 59,031. They knew that the dividend had been 6 per cent. Of course they could have paid 6 per cent. this year, but for reasons it was considered wiser to pay 5 per cent.; but was 6 per cent. an unreasonable return for such a venture as their undertaking? It could not be compared with Paris, Vienna, St. Petersburg, or any other city cast in their teeth. The amount of the subscriptions there did seem less; in fact, they were much larger in some places, and they were larger notwithstanding they were free from things which affected the National Company most seriously. As far as he knew, in Berlin and Paris, and in the great cities where the telephone enterprises had fallen into the hands of the State, there were no wayleaves, there was certainly no 10 per cent. on the gross receipts payable to the State at the risk of somebody else. He was sure that many of those were worked at a loss. As far as the London charge of £20 was concerned, that was perfectly illusory. It was quite true that they had some subscribers who paid that, but if they subscribed for a term they got it for less. Then, to attach a subscriber to the telephone, they must put down £42. It was not unreasonable to charge a high rate for a short tenure, but that £20 was quite a fallacy, because the average during the past year had been £15. 0s. 7d. in London. This could not be compared in the same sense with other cities. The whole area of London was included in the subscription. In Berlin, Paris, and other cities the State did not pay much for wayleaves; in London they paid £1. 4s. for every subscriber, and they paid £1. 6s. 9d. royalty to the Post Office. Thus there was £2. 10s. out of the £15s. 0s. 7d., and if that was deducted from the £15, he maintained, looking at the area covered and the circumstances under which the business was carried on, London was the cheapest city in the world. Leaving London out of consideration, the charge all over the country for an annual subscription to the wires averaged £8. 16s. 10d., but including London it was £9. 16s. 10d. In each of those cases the same thing held good about wayleaves and Post Office royalty; take those off, and the cost was materially diminished, and that they were bound to do to make a fair comparison. The Company deserved to be understood, and they were entitled to some fair comparison with what they did and what their models did. The net results of the year, deducting those royalties, amounted to £30,475. They proposed to pay on the major quantity of orders 5 per cent.; they could have paid another 1 per cent., but they had had to consider the character of the business, whether it was not a prudent thing to pay a dividend that was not so bad in these times, and which as time went on and consols diminished in value would be brilliant, and would be something in the nature of a permanent 5 per cent., with a strong reserve. That had appeared to have excited a difference of opinion, which he detailed by reading two letters from shareholders. Considering all the circumstances of the case, the Directors concluded that it was their duty to recommend the acceptance of the reduction of dividend, but with the great enhancement of the security of the property. Coming to deal with general matters, he first referred to paragraph 8. That was a story that had to be told. That was a case in which many people signed a paper and were promised the impossible, and they believed it; but the very people who promoted that company (the New Telephone Company), when they sat down and under the inspiration and the knowledge of the National Telephone Company appreciated their position, they saw the wisdom of coming to terms with the National, who, in turn, thought it prudent to come to terms with the former, and that paragraph exhausted the whole story. They were in the midst of those negotiations under which they were to become partners when the new policy of the Government was launched, and the late Duke of Marlborough was pretty well puzzled what to do about the Government, and so was the speaker. One of the oddest things was that the competitor of this Company, the duke, was immediately brought into close connection with the Directors to see what could be done. What had to be done was to fuse it with this Company. They had had a touch of competition at Manchester: the rates were lower, but the convenience of the public was not assured. The Post Office had the right of taking over the telephone company any day they liked by agreement. The Post Office agreed that the most difficult, costly, and sensitive part of the business should be committed to a company, but they would keep the arterial process in their own hands. So far as the Government policy went, it seemed to be one of disruption. He referred to the negotiations proceeding with the Post Office for the purchase of the Company's trunk lines, and said there would be conflict, and without suggesting that anyone connected with the business would be influenced in the slightest degree to protect the telegraph revenue, they had to submit their judgment to theirs, and certain things they would now have to refer to the Post Office. That was one matter that was acting to obstruct the development of telephones. The Post Office held the trunk lines, and intercommunication was to go on through that medium. The National would pick up the business, the Post Office would send it, and the National Company would drop it again. That agreement would be in their hands in a short time, and he hoped the public would like it. He then referred to the introduction of new directors Lord Balfour of Burleigh and Sir Albert K. Rollit, M.P., and moved the adoption of the report and accounts, and the payments of the dividends recommended.

The **Right Hon. Lord Balfour of Burleigh** seconded the motion.

The **Chairman**, in reply to questions, observed that the amount of £397,580 represented the cost of acquiring the shares in the New Telephone Company, and what they held in it. The reserve fund was invested in the Company's business, and as it grew larger they would have to consider whether to invest it in securities or not. The Company were informed of the desire of the Corporation of Glasgow to establish a local telephone service, but the working of it was a matter that could be predicted. They knew what had happened in Manchester, where subscribers found the necessity of subscribing to two exchanges, instead of one, to get what they wanted. That must be so, and the Company had no intention of vacating Glasgow, where, if the Postmaster-General granted a license, the same difficulties would be met with as at Manchester—a divided service, a certain loss on the undertaking. He thought the Government would have to buy up the telephones long before the license expired, and that they would have to make some provision for what might arise; hence the necessity for a moderate dividend and a big reserve. He then put the resolution, which was unanimously adopted.

The retiring Directors (Lord Balfour of Burleigh, Mr. C. Swain Agnew, Mr. G. Hunter Robertson, and Sir Albert Rollit, M.P.) were re-elected, and Messrs. Welton, Jones, and Co., the auditors, were reappointed.

A vote of thanks to the chairman terminated the proceedings.

ELECTRIC CONSTRUCTION CORPORATION, LIMITED.

An extraordinary general meeting of this Company was held yesterday at the Cannon-street Hotel, E.C., under the presidency of Sir Daniel Cooper, Bart. (chairman), to confirm the resolutions passed at the previous meeting for the voluntary liquidation and reconstruction of the Company, and which resolutions were printed in our issue of June 30.

The Secretary (Mr. J. Gray) read the notice and the resolutions passed at the previous gathering.

The **Chairman**, after a brief speech, explaining the resolutions, moved them.

Mr. Barclay seconded the resolutions, which were unanimously adopted.

The **Chairman** then moved, and **Mr. Plunkett** seconded the appointment of Mr. P. E. Beechcroft and Mr. E. Garcke as liquidators. This motion was adopted, and the proceedings terminated.

EASTERN TELEGRAPH COMPANY, LIMITED.

The forty-second half-yearly ordinary general meeting took place on the 13th inst. at Winchester House, Sir John Pender presiding.

In moving the adoption of the report and accounts, the **Chairman** stated that the gross revenue for the half-year ending 31st March last amounted to £372,852, being a decrease of £9,355 as compared with the same period of the previous year. The reduction in the gross revenue was due to their having received £17,700 from their investment in the Eastern and South African Telegraph Company, as against £29,580 in the corresponding period of the previous year. The ordinary expenses for the half-year totalled £102,499, as against £105,820 in the same period of 1892. After making provision for interest on debentures, debenture stock, and preference shares, they were able to propose the usual final dividend of 1¼ per cent. and a bonus of 1¼ per cent. thus making, with the interim dividends already paid, a total distribution of 6¼ per cent. for the year ended March last, and to carry £88,000 to the reserve fund as against £68,000 in the previous year. He thought they had materially improved their position during the half-year, and then moved the adoption of the report and the payment of the dividends and bonus recommended.

The **Marquis of Tweeddale** seconded the motion, which was adopted.

WEST AFRICAN TELEGRAPH COMPANY, LIMITED.

The eighth ordinary general meeting of this Company was held on the 13th inst. at the offices, Winchester House, E.C., Sir John Pender, chairman, presiding.

The report, which was taken as read, stated that the revenue for the year ending December 31 last amounted to £60,922, against which £20,018 was charged for ordinary expenses, £13,964 for expenditure relating to repairs of cables, etc., and £801 for income tax, leaving a balance of £26,137. From this amount was deducted £23,726 (being for interest on debentures £13,060, and for sinking fund £10,666), leaving a balance of £2,411, which it had been decided to carry forward.

In moving the adoption of the report, the **Chairman** expressed regret at the large increased expenditure (£11,000) in cable repairs, and at the further loss of £8,000 on exchange; but the Directors were doing everything possible to minimise the loss in the future. He then moved the adoption of the report and accounts.

Sir Henry C. Mance seconded the motion, which was carried.

BUSINESS NOTES.

Bristol.—Dynamo attendants, strokers, and drivers are required at the Bristol central station.

Glasgow.—The new telephone switchboard, about which so much has been written and said, is now in work.

Cardiff.—It has been decided to make provision for electric light in the new Cardiff museum and free library.

Richmond.—Active steps are being taken by Messrs. Latimer Clark, Muirhead, and Co., at Richmond in extending the street electric mains.

Richmond Fire Calls.—The Corporation of Richmond ask for tenders for fire calls to be laid within the borough. An advertisement appears this week.

Partner.—An electrical engineer (Mr. Bennett, 44, Fishergate, Preston) having completed a large electrical supply station, is wishing to find a partner with capital.

Globe Telegraph and Trust Company.—A balance dividend of 4s. per share is proposed, making a total payment for the year of 4½ per cent., carrying forward a balance of £1,287.

Chester.—Mr. Preece has submitted a report, and assuming the site to be the Hop Pole Paddock, and a low pressure system be adopted, the cost for the initial installation is estimated at £15,000.

Blackpool.—Tenders for wiring and fitting electric lights in the Town Hall and market place at Blackpool are to be sent in by Saturday, the 22nd inst., to Mr. G. Hesketh, borough electrical engineer, Princess-street, Blackpool.

Halifax.—As seen in their advertisements, the Halifax Corporation require tenders for engines, alternators, exciters, and boilers. Those for engines and dynamos are required by 28th inst., and for the boilers by August 4th.

Dorset Asylum.—The tender by Mr. F. M. Newton, of Taunton, has been accepted for the lighting of the Dorset County Asylum. The installation will consist of about 1,000 incandescent lamps. Taunton dynamos will be used, coupled direct to Willans high-speed engines.

Western and Brazilian Telegraph Company.—The receipts of this Company for the week ended July 14, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,346.

Eastern Telegraph Company.—This Company notify that the coupons on their 5 per cent. debentures, due August 1 next, will be paid on and after that date at the banking house of Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, E.C.

Croydon.—The statement that the Croydon Town Council had resolved to adopt the electric light in the centre of the borough, at an estimated cost of £25,000, is contradicted. The Council deferred consideration of the matter until a future occasion.

Telegraph Construction and Maintenance Company.—The transfer books will be closed from the 17th to the 25th inst. inclusive, preparatory to the payment of an interim dividend of 12s. per share to all shareholders on the register on the 17th inst.

Middlesbrough.—The question of electric lighting is now receiving the attention of the Middlesbrough Corporation, and an Electric Lighting Committee has been appointed to deal with the matter. The borough engineer of Middlesbrough is Mr. E. D. Latham, C.E.

Winchester.—The Town Council of the city of Winchester have appointed Messrs. Morgan Williams and King as consulting engineers to adjudicate in the matter of the award of the premium offered for the best scheme delivered to them for the electric lighting of the city.

Hanley.—At the meeting of the Hanley Town Council, on Tuesday, the Financial Committee recommended that application should be made to the Local Government Board for an order consenting to the creation of stock for amounts, amongst others, of £21,000 for electric lighting.

Oswestry.—At a special meeting of the Oswestry Town Council on Monday it was decided to grant a provisional order to the local electric lighting company, of which the Mayor (Mr. Corrie) is the chairman. The terms to be inserted in the order are similar to the Wrexham and the Altrincham orders.

Hammersmith.—The Electric Light Committee of the Hammersmith Vestry have appointed a sub-committee of 12 to report as to the experiments now proceeding in regard to the destruction of house refuse, and to go into the whole question of electric lighting generally, and to report on these matters.

Anglo-American Telegraph Company.—It has been resolved to declare an interim dividend for the quarter ended June 30 of 12s. 6d. per cent. on the ordinary stock and 25s. per cent. on the preferred stock, less income tax, payable on August 1 to the stockholders registered on the books of the Company on July 10.

Bath.—Mr. Massingham, in consequence of his numerous engagements has resigned the position of managing director of the Bath Electric Lighting and Engineering Company, and the company's chief engineer, Mr. G. F. Metzger, has been appointed general manager. Mr. Massingham remains a director of the company.

Lambeth.—The appointment of the Electric Lighting Committee of the Lambeth Vestry has been held over for a year. The provisional order obtained by the Vestry only extends to next June, and if by that time the Vestry has not laid down electric mains in the trunk roads of the parish, the Board of Trade may revoke the order.

Portsmouth.—Owing to the fact of the Portsmouth Corporation loan for some £200,000 for electric lighting and other purposes, being put on the market at the time the India 3 per cent. stock was asked for, only few applications (for £93,000) were received. The Corporation have decided to communicate with the National Provincial Bank.

Bradford.—A meeting was held on Wednesday at Bradford, at which Lord Kelvin attended to answer questions on the proposed extension of mains. His answers will be put into the form of a supplementary report, corrected by him, and will be placed before the Gas and Electricity Committee. Lord Kelvin approves generally the plan put forward by Mr. Baynes.

Chelsea Electricity Supply Company.—This Company have completed the laying of mains and are now supplying current in the following streets lately added to their area of supply: Cheyne-gardens, Cheyne-walk, Chelsea-embankment, St. Leonard's-terrace, Tedworth-square, Tite-street, Ralston-street, Durham-place, Oakley-street, King's-road. Large additions to plant and further extensions of mains are being made.

Electric Railway from Waterloo to the City.—The Unopposed Bill Committee of the House of Lords last week passed the Bill authorising the construction of an underground electric railway from Waterloo Station to a point in the City almost opposite the Mansion House. No intermediate stations will be placed on this railway between the commencement and termination of the railway. The scheme has already received the sanction of the House of Commons.

Direct United States Cable Company.—The Board have resolved to recommend a final dividend of 3s. 6d. per share, free of income tax, such dividend to be payable on and after the 29th inst., making, with the interim dividends already paid, 3½ per cent. for the year ended June 30 last, and after placing £3,000 to reserve fund account, carrying forward a balance of £819, 2s. 4d. The transfer books of the Company will be closed from July 14 to July 28, both days inclusive.

Lancaster.—Major-General Crozier, R.E., held a Local Government Board enquiry last week into an application made by the Lancaster Town Council for sanction to borrow £25,000, the

estimated cost of a system of electric lighting installation for the borough, to be provided by the Brush Electrical Engineering Company, of London. Only the main streets in the centre of the town are to be lighted at first, but arrangements are being made for additional plant to be put down as required.

Aberdeen Electrical Engineership. The Gas Committee of the Aberdeen Town Council last week considered finally as to their recommendation to the Council on the question of the appointment of an electrical engineer. Prof. Kennedy was present at the meeting, and his recommendation having been considered, the committee agreed to submit the following four names to the Council: John Christi, Glasgow; E. T. Ruthven Murray, Larne; Alfred H. Gibbings, Sussex; and Frederick A. Nixon, London.

Continental Edison Company. The Compagnie Continentale Edison having ceased manufacturing their dynamos and other apparatus in France, has disposed of its works at Ivry sur Seine to the Compagnie de l'Industrie Electrique of Geneva. This latter company has begun the manufacture of Thury dynamos and apparatus in France to satisfy the enquiries and orders received from that country, as the municipal councils will only grant concessions for electric light on condition that all the material is made in France.

The Squire's Engine.—Under this name Messrs. Merryweather have produced a vertical engine and boiler, mounted on a carriage, which can be used, as occasion requires, for driving a dynamo to light the squire's house, chaff cutting for the squire's horse, or, hitched to this same horse, as a fire engine to put out the fire at a hayrick or in one of the houses down in the village. It is the sort of engine a consulting engineer might find useful to specify for those country gentlemen who like their apparatus arranged to kill two birds with one stone.

City and South London Railway Company.—The receipts for the week ending July 16 were £774, against £766 for the same period last year, or an increase of £8. The total receipts for the second half year of 1893 show an increase of £344 over those for the corresponding period of 1892. The accounts for the past half year admit, after paying debenture interest and dividend on the 5 per cent. preference shares, a dividend on the ordinary stock of ¾ per cent., as against ½ per cent. at the corresponding period last year, with £898 carried forward.

European Gas Company. At the annual meeting of the European Gas Company, the chairman, Mr. J. Blacket Gill, said that during the past year he had paid a visit to their stations, accompanied by the general manager, and he noticed that the electric light had gained ground during the last two years. The Company had a large business in the middle of the day with stoves and engines. They had about 38,000 stoves on hire besides 250 gas engines, the result being that about 25 per cent. of their total consumption was in the daytime.

Dublin Tramways. The half yearly meeting of the Dublin United Tramways Company was held on Tuesday. The chairman (Dr. Carte) stated that the traffic receipts for the half year showed an increase of £4,200, and the number of passengers carried, an increase of 900,000. The company were urged by one of the shareholders to employ electric power, and the chairman stated that the company working the tramway between Dublin and Dalkey were applying for power to use electricity, and if the results there proved satisfactory their company would also adopt that plan.

Leeds.—At its meeting last week the Corporate Buildings Committee of the Leeds City Council talked over the desirability of acquiring new plant for working the electric lighting apparatus at the Municipal Offices and the Town Hall. The committee has long been convinced that the existing machinery is totally inadequate for maintaining the requisite amount of illumination and have at last resolved to urge upon the Corporate Property Committee the desirability of purchasing new apparatus. The sum of £10,000 or £12,000 is mentioned as the probable outlay that would be requisite.

Madras Tramways.—The statement that the Government has refused the extension of time asked for by the Madras Tramways Company is confirmed, says the *Indian Engineer*. The company thus loses the concession and forfeits the 10,000 rupees deposit paid to the Municipal Council. It is not known yet what steps the shareholders are likely to take, but it is expected that they will lose all the paid up capital on the four rupees shares. An effort will probably be made to induce the Government to reconsider its decision. The present failure is considered a death-blow to the prospects of any tramways in Madras.

Poplar. The Poplar District Board have received a report from the Works Committee, in which they recommend that the clerk should report to the committee on the subject of electric lighting, in view of the Act of Parliament confirming the Poplar electric lighting order and the position of the Board in the matter. Mr. Booth called attention to a statement made that St. Pancras was making a profit out of the electric light. He thought the committee should have some figures, especially as nothing had been mentioned anywhere about profit from the electric light in St. Pancras. This was agreed to, and the clerk was instructed to report.

Oban. A communication was read at the last meeting of the Oban Town Council from the Caledonian Electric Supply Company, Limited, giving notice that an application was intended to be made on or before December 21 next, by memorial to the Board of Trade, whereby it is proposed to authorise the company to supply electricity for any public or private purpose within the district area comprised within the municipal boundaries of Oban. The meeting considered the proposal as one of great importance, and the letter was remitted to the Lighting Committee with an injunction to give it early consideration. Few towns in the country are so highly rated as Oban in the matter of its gas. Over 8s. per 1,000ft. is rather a stiff figure to pay, especially where there is a large consumption.

Chatsworth. The Duke of Devonshire has decided that Chatsworth is to be lighted with electric light, and after careful consideration, he has accepted the scheme proposed by Mr. Bernard Drake, of Drake and Gorham, Westminster. His proposal is to obtain the whole of the necessary horse power from a large pipe already laid for the supply of the well known Emperor Fountain. He estimates that from this source he can obtain up to 150 h.p., which will amply suffice for all requirements. The turbine house is being built outside the gardens, and in order to avoid an eye sore it will be sunk entirely out of sight. The number of lights to be fixed at present are about 700, which will be ready for use in September. The installation will be very interesting, as being the largest utilisation of natural forces which has been attempted at any country house up to the present.

Sheffield. The second ordinary general meeting of shareholders of the Sheffield Electric Light and Power Company, Limited, was held last week at the company's offices in Commercial street. A dividend of 5 per cent. per annum was declared free of income tax, and the retiring directors were re-elected. The chairman, Mr. George Franklin, explained that in view of the undoubted growing demand for electric light it had been found necessary to rebuild and enlarge the central station in order to make room for new machinery. The new steam and electrical plant would be of the most modern description, and would probably be at work during the present autumn. The station would have an ultimate generating capacity of 80,000 lamps. Twelve and a half miles of underground conduits had been laid in the streets for the reception of the distributing cables. The prospects of the company were most encouraging, and a new issue of 4,000 ordinary shares would be probably made in the near future.

South London Fares.—In the House of Commons on Monday Mr. Byles asked whether the City and South London Electric Railway Company charged fares exceeding a penny per mile for the distance actually travelled by the passenger; that on these fares exceeding penny per mile no passenger duty had been paid; on what grounds this privilege had been permitted to the City and South London Railway; and on what terms other railways may obtain a participation in this privilege. Sir J. Hibbert said: "The facts are not accurately stated in the question. The company are held liable to pay duty on fares charged at a rate exceeding a penny per mile for the distance actually travelled. It is, however, a matter of great difficulty to determine the extent of the liability, owing to the special method adopted by the company for the payment of fares. An arrangement has been arrived at between the Commissioners of Inland Revenue and the company, under which the Commissioners are satisfied that the liability of the company is fully discharged."

Weston super-Mare.—At a committee meeting of the Weston-super-Mare Board on June 27, Mr. Paris, the representative of the Brush Electrical Engineering Company, Limited, attended and explained the nature of his company's system of lighting, and stated that his company would be prepared to make a plan and prepare an estimate of the cost of the works gratis. On the proposition of Mr. Pethick, seconded by Mr. Beedle, it was resolved "that Mr. Paris be requested to give the Board the best proposal for the purchase of their provisional order for a term of years, having regard to the fact that any condition for the payment of undefined goodwill will not be entertained by the Board, and alternatively by a proposal for the erection of works for the supply of electricity, together with approximate estimate of outlay necessary supposing the Board were to undertake its own works." The clerk was instructed to write to the authorities at Bradford, asking for information on the subject of obtaining money to carry out electrical lighting works.

H.M.S. "Resolution." — The new first class battleship "Resolution," which left the Tyne for Portsmouth last week, is lighted throughout with electricity by an installation of about 700 electric lamps, and is also equipped with four electric search-lights of 25,000 c.p., each of which will be worked by a dynamo under protection. Means are so arranged that the ship when in action can be entirely controlled from either of the two conning towers. The vessel is fitted with twin screw engines, each set having cylinders 40in., 59in., 88in., by 51in. stroke. There are eight single ended boilers, each 15ft. 6in. diameter by 9ft. 6in. long, having in all 32 furnaces, 155lb. working pressure. There are no less than 69 auxiliary engines, including steering engine, electric light engines and dynamos, air-compressing engines, distilling engines, evaporator engines, boat hoisting engines, workshop engines. The "Resolution" is 40ft. longer, 5ft. broader, and has 3,680 tons more displacement than the ill-fated "Victoria." As a flagship she will have a complement of 700 men on board.

Manchester.—The engines, boilers, and dynamos at the Manchester electric lighting station have been running for the past few days, and have been tested with satisfactory results. Arrangements are being made for the formal opening of the works on an early date. Some 50 shops and warehouses in and about Market street have been coupled to the electric mains, and enquiries and applications with regard to the terms of supply are being received daily. The current was turned on in some of the offices of the Town Hall for the first time last week. In the presence of the members of the Gas Committee, the Lord Mayor (Alderman Marshall) switched on the light in the committee-room of the gas

department, and although the arrangement of the lamps at present is only of a temporary character the result was most satisfactory. The Lord Mayor after expressing regret at the absence of Sir John Harwood, chairman of the Electric Lighting Sub Committee, and Councillor Brooks, chairman of the Gas Committee, congratulated the committee on the satisfactory completion of the works so far, and expressed a hope that the supply of the electric light to the public, which it is intended shall begin in the first week in August, would be equally satisfactory.

Moffat.—At a meeting of the Commission last Friday, reports by engineers with respect to the proposal to introduce the electric light into Moffat were considered. Mr. David J. Brown, in moving that the proposal of Messrs. Woodhouse and Rawson, Glasgow, be adopted, utilising water power of the Evan river, two miles from the town, said that the engineers stated if the charge were 8d. per unit for the light sold, they calculated that the Commission would make a profit of £1,600 off the private light yearly. But as the Commission would have to make the light cheaper than gas, if they calculated the charge at 6d. per unit there would be apparently a profit of £958. Even though only the half of the light was sold, the profit would be sufficient to repay the capital expenditure in a few years. Mr. Peter Richardson seconded. Provost Young remarked that in all the engineers' reports received the amount of light and profits were altogether matters of assumption. There was not sufficient exactness of data to warrant the Commissioners in proceeding with any scheme. Until electric lighting was less of an experiment and they had more definite information, he moved that no further action be taken. Bailie Knight seconded, and the amendment, that the matter be adjourned, was carried by a majority of two votes.

St. Pancras.—Mr. Gibb, vestry clerk of St. Pancras, has replied to the pamphlet of Mr. Clements on the electric lighting in that parish. He contends that the original estimate of cost has only been exceeded by 8 per cent., and not doubled, as stated by Mr. Clements. Additional works not at first contemplated have been added, and these of course increase the outlay. The cost of the production of the light is rather less than more than the estimate. The £6,500 stated to be a yearly loss was purely mythical, as well as the probable future loss. Mr. Gibb denies that the consumers were ever told 4¼d. or 4½d. per unit would be charged instead of 6d. It was, he asserted, quite correct to estimate £4,000 profit on the current year, and the estimates for the new installation in King's road were as reliable as those upon which their present installation was authorised, and more complete because they had been tested by local experience not available in 1889. After discussion, it was decided to hold a special meeting to consider together the allegations of Mr. Clements, the replies of Mr. Gibb and Prof. Robinson, and other facts connected with the case. The consideration of the Dusting and Slopping Committee's recommendation, that there should be a combined dust-destroying and electric light station in King's road, was deferred to the same meeting.

Guildford.—At the meeting of the Guildford Local Board last week the town clerk read a notice he had received from the Holloway Electricity Supply Company, 34, Victoria street, Westminster, of their intention to apply on or before November 21 next for a provisional order to supply electricity in the borough. Alderman Mason asked whether, supposing the company got the provisional order, they would have a monopoly of lighting by electricity within the borough. The Town Clerk replied that they would not. Mr. Salsbury did not see how it could be any injury to the town. He did not think they could oppose the application, unless they intended to get a provisional order themselves as a council. Alderman Allen said they had already determined not to do that, and therefore he thought they should be only too pleased if someone came and supplied them with electricity. Mr. Cable said the Council had decided to assist any company, under certain conditions. Alderman Carling thought that all that was necessary was to see that the company was one of proper standing. Mr. Colebrook asked if it were not worth while to see if the Corporation could supply the town with electricity, and not let an outside company come in? The Mayor said that had been before them, and they could not see their way to do it. The matter then dropped, the Town Clerk remarking that the application would come before them again later on.

Leicester Co-operative Society.—A meeting was held of the Leicester Co-operative Society last week to discuss the question of lighting the whole of the central premises of the society by means of electricity. Mr. Neale moved that the committee be empowered to adopt the principle of electric lighting for the central premises. As co-operators and friends of social progress they would but be doing right in taking action in the matter, and it would be bound in a short time to be a paying concern. The society had been of opinion for a long time that they ought to wait, but so far as he could see they had arrived as nearly as possible at perfection with the light. From both a sanitary and financial point of view they ought to take up the matter, which was of great importance to them all. Mr. Yates moved as an amendment that it be deferred for six months. Mr. Newton supported the proposal to introduce electricity, and quoted statistics to prove the financial success of many electric lighting systems in London. A most animated discussion ensued, in the course of which Mr. Bond mentioned that in consequence of the successful results of their efforts in other towns the Midland Railway Company had decided to lay down an installation for a portion of their works at Leicester. Mr. Harrott, the secretary, said the figures he gave at a previous meeting were thoroughly reliable. He believed they could obtain a good installation for £1,000. They wanted a first-class system, and he would be opposed to opening the tendering to competition and adopting the lowest estimate. On a vote being taken, it was decided by 79 votes to 27 to give the committee the necessary authority to proceed with the electric lighting system.

Huddersfield.—In a month or two, says a note in the *Manchester Examiner*, Huddersfield will have a public supply of the electric light available. The works are large enough to contain machinery capable of generating electricity to supply 20,000 lamps, each of 16 c.p., together with reserve plant. There is also ground upon which the building can be enlarged at the northern end. The machinery already put in will provide for 9,000 eight-candle lights; but it has been found necessary to double the capacity of the machinery in order to meet the great and unexpected demand for the supply of electric lighting, and it is hoped that the whole power will be ready for putting in operation by the 31st of October. The electric generating machinery consists of a high-tension alternating current plant having an output of 250 units. Four boilers of the Babcock and Wilcox type have been fixed equal to 800 h.p. in the aggregate, supplying steam to three compound vertical condensing high speed engines, which drive three Mordey alternators, which supply electricity at a pressure of 2,000 volts. The additional productive power referred to above will be provided by one large machine generating 250 units. This plant is supplied by the Brush Electrical Engineering Company. The lighting of the station will be by means of arc and incandescent lamps. The current is to be conveyed from the works along four primary mains run in conduits, which are paper tubes bedded in bitumen, and protected by cast-iron casing. These have been laid by Messrs. Callender and Co., of Leadenhall street, London. The primary mains or cables along which the current is conveyed are of the concentric type and have been supplied by Messrs. Siemens Bros. and Co., Woolwich. The conduits and mains are laid to embrace the chief thoroughfares within a certain area. Seventy-five public bodies, persons, or firms have arranged to take the electric light. The demand is equivalent to about 9,000 8-c.p. lamps, for which provision has already been made, and it is said that a comparison of other towns which have had the start with the new form of lighting, discloses considerable enterprise on the part of the Huddersfield people. The charge made for the supply of electricity will be at the rate of 6d. per Board of Trade unit.

Three-Wire System at Bradford.—The following is Lord Kelvin's report to the Gas and Electricity Committee of Bradford on the proposed extension of their system: "I have duly received the printed reports of Mr. Sydney Baynes and Mr. James Shoolbred and other documents sent to me in accordance with your instructions. I have also had a full discussion of the whole subject in conference with Mr. Baynes and Mr. Shoolbred, and I have since received a chart and some further information from Mr. Baynes. After careful consideration of the whole subject, I now report as follows: (1) In my opinion the best arrangement for improving and augmenting the electricity supply according to the present limited demand of the committee is that recommended by Mr. Baynes and described in his printed report, according to which a third conductor is brought back to the generating station, and all the adjustments to give proper electric pressure to the consumers are performed at that station; (2) the method proposed by Mr. Shoolbred, whether for a three-wire system or a five-wire system, according to which the adjustments of the pressure for the consumers at different parts of the system are entrusted to automatic mechanism at the feeder ends, is not adapted to give in ordinary circumstances the requisite uniformity of pressure to the consumers, and is liable also to serious dangers and objections; (3) I do not think it probable that when the time comes for extensions to greater distances it will be found advisable to adopt the five-wire system, or to go beyond the three-wire system; (4) it seems to me probable that the best and most economical plan for extending to much greater distances than those covered by the system now in use will be by the establishment of a second generating station in some convenient position at a distance of not more than one mile and a half from the present generating station; (5) I have carefully considered the question of 'simple shunt' or 'compound winding' for the balancing motor generator, and although I am informed by Mr. Baynes that compound wound motor generators are now in use at Southampton, and give good results there, I believe that simple shunt winding will be found to give equally good results in ordinary use, and to be safer in respect to contingencies of possible occurrence."

Windsor.—At the last meeting of the Windsor Sanitary Authority, the town clerk read some correspondence from the Board of Trade on the subject of the Windsor and Eton Electric Light Company with respect to the question of the revocation of the order. The Board of Trade point out that the Windsor Company have failed to satisfy the Department that they are in a position fully and efficiently to discharge the duties and obligations imposed upon them by the order, as required by Section 7, and that, in these circumstances, it devolves upon the Board of Trade to consider whether they should not revoke the order. Before, however, taking this course, the Board of Trade hold themselves prepared to receive any observations which the company may desire to offer on the subject. Mr. Sydney Morse on behalf of the Windsor Electric Light Company, had written: "You no doubt are aware of the difficulties there have been for some time past in the money market which have prevented the progress in raising capital for electric lighting schemes. Clients of mine (other than the Windsor Company) are anticipating the issue of a large amount of capital, portions of which will be available for such schemes as that of the Windsor and Eton Company. Though I cannot pledge these clients at the moment to find the required capital for the Windsor Company, they write me that it seems more than probable that in time they will come to the assistance of the Windsor Company if

the position proves locally to be as good as is represented. Meanwhile, the company has erected plant and is supplying current as far as possible in the district, fully anticipating that before very long they will be able to obtain further capital and extend their operations throughout the entire area. Under these circumstances, I trust the Board of Trade will permit the consideration of the question of revocation to stand over for the present." The Town Clerk suggested that the best course to adopt would be to again appoint a committee of all the members of the Council who were not interested in either gas or electricity, to see the electric light company and find out whether the company would be likely soon to be in a better financial position and be able to comply with the Board of Trade requirements. This seemed to be universally approved, and the suggestion was adopted on the proposition of Councillor Cantrell, seconded by Councillor Dyson.

Birmingham.—The question of electric lighting is dealt with by the General Purposes Committee in the report to be presented at the next meeting of the Birmingham City Council. Notice having been received from the Birmingham Electric Supply Company of their intention to apply during the present year to the Board of Trade for a further provisional order, an interview between the special sub committee appointed for the purpose and representatives of the company took place. The intention of the company is to ask for authority to supply electricity in the Edgbaston district and the jewellers' quarter, but with extended areas. The committee had, they state, to consider whether they would permit the existing company to extend their area, or whether they would withhold their consent pending an application for an order by the Corporation themselves. It was felt that consent could not be fairly withheld on any other ground, and that if a Corporation order were applied for, it would probably be necessary, for the successful development of the installation in the hands of the Corporation, that terms should be arranged with the Electric Supply Company for the purchase of their existing undertaking. The reasons generally put forward in favour of the supply of gas and water by corporations do not seem to apply with nearly the same force in the case of electricity. There is no monopoly of supply under the Electric Lighting Act, 1882, as in the case of of gas, nor is the supply of electricity like that of water, an absolute necessity of existence. The disturbance of the streets is very slight, and the practical control of the same is already secured by sufficient clauses, while it can scarcely be expected that there will be any economy in working expenses in the hands of the Corporation. The commercial value of the company's undertaking can hardly be estimated, but it is evident that in Birmingham, at all events, it has to meet a serious competition with a cheaper gas supply. The taking over of the supply of electricity by the Corporation would necessitate a large addition to capital expenditure at the present time, and it is not likely that this expenditure would be highly remunerative. On the whole, the committee recommend that the proposed order of the Electric Supply Company be not opposed, except upon clauses, and that the application and the draft order, when submitted, be referred to the committee, with power to take such action as they may think desirable for protecting the interests of the consumers and the Corporation.

Aberdeen.—The state of electric lighting in Aberdeen is thus summarised by the *Scotsman*: "Following the example of the municipal authorities in a large number of towns in England and Scotland, the Town Council of Aberdeen applied to Parliament for an Electric Lighting Act, and are now busily engaged in carrying out its provisions. The compulsory schedule of streets—that is, those thoroughfares which it was necessary under the Act to light within two years of the passing—were few in number, and lay entirely in the centre of the business part of the city. Acting under the advice of their engineer, Prof. Kennedy, the Town Council decided to extend the area in which current will be first supplied over what is practically the whole of the business portion, and nearly as far west as the end of Union street. Distributing mains will accordingly be laid along Castle street, Union street to Bon Accord street, Union terrace, Rosemount viaduct, Schoolhill, George street, Upper Kirkgate, Broad street, and Market street. It is proposed latter on, if the demand for light should increase as fast as it has done in other cities where light is now to be supplied, to extend the lighting area to the very west end of the city, and so cover a large residential district there, a district which is to Aberdeen what the west end terraces are to Edinburgh. As showing the increasing demand for the illuminant in Glasgow, for example, the original order was for 12,000 lamps lighted at one time of 8 c.p., which would mean about 18,000 lamps actually connected, and already, although the station has only been running about a couple of months, applications have been received, we understand, to connect more than 27,000 lamps, and the applications are constantly coming in, so that the Corporation have had to extend their plant. Aberdeen is one of those cities in which the gas is under the control of the Town Council, and the gasworks lie at the east end of the town, about half a mile beyond Castle street. It happened very fortunately, seeing that the management of the electric lighting and of the gas will be so nearly connected that an excellent site for a central station was found to be available upon a plot of land adjoining the gasworks. In these circumstances, the gas coke, which it is proposed to use for fuel at the station, can be delivered direct into the fuel bunkers from the existing lines of rails within the works themselves. The central station, so situated, is now in process of erection, the walls being already 14ft. or 15ft. above the ground. The total cost, exclusive of land, but including buildings, was estimated by the engineer to be £24,400; but the actual cost, now that the tenders have been received, has been found to work out very considerably less than this figure. There is good hope that the work will be completed by the end of the year. It is proposed to charge 7d. per Board of Trade unit for the current."

The Roundhay Electric Trams.—The following letter from Mr. W. S. Graff Baker appeared in the *Leeds Mercury* of the 17th inst., with reference to the Roundhay electric trams: "My attention has been called to a second communication on the subject of the stoppage of electric cars, signed by 'A Frequent Passenger,' which has appeared in the columns of your paper. This communication is scarcely worthy of attention, but as it is possible that many people in Leeds do not clearly understand the position of the electric tramway *vis a vis* the Corporation, it may be well to take this opportunity to explain. The installation on Roundhay-road was put in for the purpose of showing to the Corporation and the people of Leeds the practical possibilities of electric traction, with a view, in the event of the impression being favourable, to extend the system throughout the borough. The present electric lines, running as they do from well outside the centre of the city to a pleasure resort, have never paid; but, on the contrary, have caused a serious monetary loss to myself since the lines were opened. This, too, notwithstanding the fact that the cost of operation is lower than that of any other tramway in the United Kingdom. But it is easy for anyone to understand that even if the total cost of operation were only 1d. a mile, if the receipts were only ½d. a mile a loss would ensue. For this demonstrative line, only sufficient plant was put in to operate it as a demonstration instead of as a commercial undertaking; and the time that it was at first thought would be necessary for the purpose of such demonstration (and to enable the Corporation to get control of the remainder of the tramways in the city) was estimated at one year. Owing to delays, which it is useless to go into at present, and of which you are well aware, the line has now been running nearly two years, and it is almost impossible, at the present time, to state when the lines will either be extended or removed. This explanation should answer the question as to why a duplicate plant has not been put down for Roundhay road. As regards the cost of operating with a reserve plant, this would not be any higher but probably lower than the cost of working with a single set of machinery. As most intelligent people are aware that the production of mechanical power on a larger scale is more economical than on a smaller, should the line be extended to twice its present length with a reserve plant, the cost would remain the same, or would be lower. It was with regret that the lines were stopped, as we always endeavour to grant every convenience to our customers; but compulsory examination of the machinery on the part of the insurers etc., have caused us, much against our will, to stop for the short time necessary to enable such inspection to be made."

Dublin Southern Tramways Parliamentary Enquiry.—The first tramway case to which the model clauses were applied was that of the Dublin Southern District Tramways Bill, which came last Friday before the Select Committee of the House of Commons, over which Mr. Samuel Hoare presided. The object of the Bill is to authorise the use of mechanical power in the working of the Dublin Southern District Tramways, and to enable the company to acquire the undertaking of the Blackrock and Kingstown Tramways Company. Mr. Cripps, Q.C., and Mr. J. D. Fitzgerald appeared for the promoters, and Mr. Pembroke Stephens, Q.C., and Mr. Clifford for the petitioners against the Bill—the Dublin, Wicklow, and Wexford Railway Company. Mr. Cripps, in opening the case for the promoters, said the point in dispute between the promoters and their opponents was a very narrow one. Really the only point was what form of protective clause should be inserted in the Bill in order to ensure that no damage should be done to the railway company's railway signals by the use of electrical power along the tramway lines. One of the purposes of the Bill was to have a thorough service in the hands of one company, and with one gauge from Dalkey to Dublin. He understood that the petitioners desired to say to that committee that the tramway company should not be allowed to use electrical power at all. If they were allowed to use it they should do so under certain restrictions. This question of protective clauses had been considered by the Joint Committee on Electrical Powers after an enquiry which lasted for a large number of days. It was shown before that committee that electrical power was both the best system from a public point of view, and, what was more important, was the cheapest. The joint committee had prepared a model clause, and he believed their report had been laid upon the table. Whether that clause was favourable to the tramway company or the railway company, the promoters of the Bill would be prepared to accept that model clause. At this point a proof of the report of the joint committee was produced and Mr. Cripps read the model clause, which stated the undertakers should, in using the electric powers of this Act, employ insulated returns or uninsulated metallic returns of low resistance. The great question before the joint committee was whether the earth return should be direct or accidental, and this clause seemed to be a compromise. Then the clause stated that the undertakers should be subject to certain regulations in the schedule, and that they should take all reasonable and proper precautions. Then there was a penalty clause. There was a proviso that this clause did not apply to electric lighting purposes. He undertook in the fullest possible way to insert that model clause. He would ask the committee under these circumstances not to ask them to call expert witnesses at enormous cost and to go over the case again. Mr. Pembroke Stephens said there were other points at issue besides that of the protective clauses. The petitioners urged that the erection and maintenance of poles and wires for the carrying of electrical currents along the tramway would be injurious to the petitioners. They also urged that powers to work the tramways

by mechanical or electrical power was in contravention of the express provisions in the Acts authorising this tramway, the Act only being passed by Parliament under the provision that the tramway should be worked by horse power. They further submitted that it would be in contravention to the order in council of the Lord Lieutenant, and that the working of this tramway by electricity could not fail to inflict injury on the petitioners. This tramway ran absolutely parallel with the railway, almost touching at some points, and at one point, at all events, actually crossing the railway. He accepted the model clause as far as it went, but the main point was whether this company should have electrical power or not. Mr. Cripps said he would call evidence on that point. Mr. Spagnoletti, C.E., was first called, and said he had examined the route of this tramway. He was of opinion that if proper protective clauses were inserted in the Bill, there was no objection to the use of electricity on this tramway from a railway point of view. Electrical power on tramways was both convenient and cheap. Cross-examined, witness admitted that everything should be done to protect the railway signals. Mr. A. Siemens, who said he had a large experience of electric traction in various parts of the world, said there was not the smallest reason why the electrical system should not be used in this case. It was a very simple case. Cross-examined, witness said the railway would be protected by the Board of Trade, and the Board of Trade could not allow a system that was likely to interfere with anything else. There was no danger if there was proper workmanship. In answer to the chairman, witness gave an instance of a continental tramway worked electrically crossing a railway on the level. Mr. Pembroke Stephens urged that if the committee were going to pass the Bill, at least they should ensure that there should be a proper local enquiry and safeguard before anything was done, so as to prevent any mischief happening. Mr. W. L. Payne, general manager of the Dublin, Wicklow, and Wexford Railway Company, was then called. He said the wires by which the signals were worked would be parallel with and very close to the proposed overhead wires for the tramway. The tramway crossed the railway. They were in an exceptional position in Ireland in reference to the main block signal stations. The staff are under the witness's control, but the maintenance was taken charge of by the Post Office. He considered that the model clause did not in this case give the railway company sufficient protection. He thought that the proper maintenance of the tramway company's electrical system would depend to a great extent upon its financial position, and if that did not become better than it was at present, it would be a very bad look out. He thought it a great hardship that the railway company should not have an opportunity of being heard before the Board of Trade before the use of electricity was sanctioned upon this tramway. Cross-examined, witness said the block system on the Dublin, Wicklow, and Wexford Railway was the best in the country. Mr. Langdon, C.E., superintendent of the electrical department of the Midland Railway, gave scientific evidence with regard to electric traction, and said if they had a tramway worked by the electrical system they must have proper protection. Mr. Cripps agreed. Mr. Harrison, general manager of the London and North Western Railway Company, was next called, and said if he was responsible for the conduct of the Dublin Railway Company, he should view the introduction of this electric tramway with the very greatest apprehension. If there was the slightest possibility of the smallest interruption with railway signals it would be a very serious matter. Mr. Cripps replied on behalf of the promoters. Mr. Clay, solicitor to the promoters, was then called to give formal proof of the uncontested portion of the preamble. After consultation with his colleagues, the chairman announced that the committee had decided that the preamble was proved, and they understood that model clauses would be put in the Bill. The proceedings were then adjourned, in order that the Bill might be brought up in its final form.

PROVISIONAL PATENTS, 1893.

JULY 10.

13353. **A new or improved means of automatically regulating the brushes of dynamo-electric machines.** Herbert Oswald Boden, 1, Walmer-place, Old Trafford, Manchester.

JULY 11.

13408. **Improvements in electric batteries.** James Henry Mason and Alfred Van Derwerken, 52, Chancery-lane, London. (Complete specification.)

13412. **Improvements in automatic regulators for electric generators.** Eugen Conrady, 56, Low-street, Keighley.

13448. **Improvements connected with or relating to motors or instruments for measuring electricity.** Felix Heinrich Aschner, 6, Lord-street, Liverpool. (Complete specification.)

13469. **Improvements in electric railway signals.** Frank Boulton Aspinall, 24, Southampton-buildings, Chancery-lane, London.

13490. **An improved electric bell.** Berthold Zetschel, 40, Chancery-lane, London. (Complete specification.)

JULY 12.

13507. **Improvements in range-finders, and in electrical appliances for transmitting the indications of the same to a distance.** Archibald Barr and William Stroud, 154, St. Vincent-street, Glasgow.

13533. **Safety insulated clip for extracting and replacing electric fuses.** Clarence D'Oyley Hutchins, Holly-grove, Feltham Hill, Middlesex.

13551. **The production of aromatic amido compounds by means of electrolysis.** Henry Edward Newton, 6, Bream's-buildings, Chancery-lane, London. (The Farbenfabriken vormals Friedrich Bayer and Co., Germany.)

13552. **Improvements in electric arc lamps.** Alfred David Lewis and Frank Michael Lewis, 6, Bream's-buildings, Chancery-lane, London.

13568. **An improved dry electrolytical process for the production of an alloy of lead and sodium or potassium.** Claude Theodore James Vautin, 1, Queen Victoria-street, London.

JULY 13.

13610. **Improvements in dynamo-electric machines.** Alphonse Isidore Gravier, 191, Fleet-street, London.

13633. **An improved electric clock.** Herman Wubbeler, 55, Chancery-lane, London.

13644. **Improvements in or relating to telegraphic type printing apparatus.** Eugene Magnin, 18, Buckingham-street, Strand, London.

13647. **Improvements relating to galvanometers.** Carl Ludwig Rudolph Ernest Menges, 45, Southampton-buildings, Chancery-lane, London.

JULY 14.

13672. **Improvements in apparatus for transmitting telegraphic indicating, and other analogous signals or movements by means of electric currents.** Andrew Betts Brown and William Falconer King, 154, St. Vincent-street, Glasgow.

13723. **Apparatus for the electrolytic production of bleaching liquid.** Carl Kellner, 46, Lincoln's-inn-fields, London.

JULY 15.

13730. **Improvements in connecting to zinc rods of Leclanche or other galvanic batteries.** Groggon and Co., Limited, 16, Upper Thames-street, London.

13749. **Improved means of working and controlling electric elevators.** Michael Holroyd Smith, 161, Trinity-road, Upper Tooting, London.

13773. **Improvements in arc lamps.** Sidney Alfred Hunter, 23, Southampton-buildings, Chancery-lane, London.

13774. **A means of maintaining the human body in electrical connection with the earth.** Eldridge Spratt, 11, Hinde-street, Manchester-square, London. (Complete specification.)

13779. **Improvements in telephone circuits.** Jorgen Jacobsen Møller, 22, Southampton-buildings, Chancery-lane, London.

13792. **Fluid operated electric switches.** Jean Joseph Paul Clariot, 53, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1880.

250. **Electric lamps.** Swan. (Fourth edition.)

1881.

4174. **Electric lamps, etc.** Brewer. (Edison.) (Third edition.)

1886.

16739. **Electric motors, etc.** Curtis and others. (Second edition.)

1889.

18923. **Dynamo electric machines, etc.** Swinburne. (Second edition.)

1892.

15319. **Electric batteries.** Federman.

17438. **Electromotor and rotary fan.** Royce.

23657. **Incandescent lamps.** Fried.

1893.

10283. **Electrode plates for secondary batteries.** Hofmann.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¼
City of London	—	11¾
— Pref.	—	12¼
Electric Construction	10	4
Gatti's	—	5¼
House-to House	5	5½
India Rubber, Gutta Percha & Telegraph Co.	10	23
Liverpool Electric Supply	5	6¼
	3	4¼
London Electric Supply	5	1
Metropolitan Electric Supply	—	6½
National Telephone	5	5¼
St. James'	—	8¼
Swan United	3½	3¼
Westminster Electric	—	5¾

NOTES.

Black Forest.—Electric transmission of power has been utilised for the cotton mill at St. Blaise, in the Black Forest.

Electrotechnology.—A manual of electrotechnology in German has recently been issued by C. Grawinkel and K. Strecker.

Genoa.—The capacity of the plant to be installed for the public lighting of Genoa will be 800 arcs. The mains will be underground.

Milan Tramway.—The inauguration of accumulator electric cars on the tramway from Milan to Monza took place on the 20th inst.

Barium Accumulator. — An accumulator whose active material is composed of peroxide of barium is used by H. Lehmann, a German electrical engineer. The liquid is a solution of barium in water.

Theatre-Lighting at Verdun.—The new theatre at Verdun is lighted throughout with electric light in two distinct currents, one fed by current direct from the mains and the other from accumulators, so that in no likely case will there be complete extinction.

Blackening of Lamps.—Elihu Thomson thinks that lamps cannot be made which will not blacken and deteriorate, if carbon be adhered to as material; "and carbon as yet seems to be the best material in existence -it is so on account of its infusibility and its apparent volatility."

Long-Distance Telephones.—It is not only to the telegraph that long-distance telephones will be rivals. The railway companies also in America, it is said, feel the effect, as many directors of companies and others who used to travel now use the telephone to talk over affairs on Board days.

Electric Fishing Boat.—The fishing boat "Matador,' owned by Mr. Schellbap, says a Sheffield paper, has just arrived at Grimsby from Bremen. This boat is moved entirely by electricity, and is a new departure altogether in the fishing trade. The vessel is now lying in the Grimsby Fish Dock, and is attracting considerable attention.

Fatal Accident.—We regret to learn of the death by drowning on Tuesday at Hampton-on-Thames of Mr. W. C. Palmer, aged 23, an electrical engineer, who was employed on the staff of the General Electric Power and Traction Company. Mr. Palmer has only recently joined this company, and his untimely death is extremely regretted by all, especially those associated with him in his profession.

Mechanical Engineers.—Among the papers to be read at the forthcoming annual meeting of the Institution of Mechanical Engineers, to be held at Middlesbrough next month, are the following: "Description of Electric Rock-drilling Machinery at the Carlin How Ironstone Mines in Cleveland," by Mr. A. L. Stevenson, of Durham; and "On the Artificial Lighting of Workshops," by Mr. Benjamin A. Dobson, of Bolton.

Lisbon.—The gas company at Lisbon has lost some of its largest customers, who have set up their own electric lighting installations. The spinning mills of Desgenatais, Westhalen-Lemaitre, and Lemaitre Bros. have been fitted up by M. See, of Lille, and the other great firm of Fouquet-Lemaitre has had electric light since 1890. This installation was supplied by Sautter-Harlé. English firms do not seem to be able to secure many installations in the district.

Electrical Indexing.—A handsome number is to hand of the technical magazine *Electrical Engineering* (565, The Rookery, Chicago), giving some well printed views of the exhibition, accompanied by a guide to the exhibits, by the editor, Mr. De Land. But the most useful feature of this journal is the extended and careful index to electrical literature, with short summaries of the interesting general articles, which no doubt proves very valuable as a "review of reviews."

Exhibition at Porto Rico.—The Science and Art Department have received through the Foreign Office particulars of an exhibition to be held in November next to commemorate the four hundredth anniversary of the discovery of Porto Rico. Exhibitors are invited to send objects that are or may become articles of commerce. Exhibits will be admitted free of duty, and no charge will be made for space. Application must be made by September 1st.

Telephones on Railways.—A paper was recently read by G. Dumont and E. Bernheim before the Académie des Sciences on the use of telephones on railways. M. Dumont pointed out that it has been only during the last year or two that telephones have been used on railways, and he investigates the conditions of their application, what uses are made of the telephone, and what might be done. M. Bernheim described the various systems of telephones utilised, and the advantages of particular forms of instruments.

Lighting of Estuaries and Rivers.—Dealing with this subject before the Maritime Congress, Mr. W. T. Douglas, consulting engineer to the Trinity House, said, with regard to electricity for this purpose, that in the form of incandescent lamps it was a source of illumination which had many advantages where the central station was not too far distant from the beacon lights, and more particularly where the central station was in the hands of port authorities. In New York Harbour the electric light was employed to define Gedney's Channel; there 100-c.p. incandescent lamps, with three loops in the filament, were attached to spar buoys placed 1,000ft. apart.

Light Diffusers.—M. Raffard, writing to the Société de Physiqué with reference to the recent proposal for making glass for arc lanterns corrugated on both sides, mentions that in 1879 Breguet supplied 30 large lamps for the Havre harbour works. At first the lantern glass was painted white, but as this obscured the light too much, he had the idea of replacing the glass by two sheets of the ordinary corrugated glass of commerce placed with the corrugations at right angles. This had the desired effect; the lantern became luminous over its whole surface, and the deep shadows were softened. The only objection is that the ground and object present a slightly mottled appearance, but this inconvenience was of no importance with the heavy work done in the shops.

Boiler Efficiency.—Tests have been made in Sheffield with Oates's automatic register as applied to steam boilers, so as to raise the efficiency without smoke. Three trials have been made—two at the works of Charles Cammell and Co., Limited, and one at Messrs. Walker and Hall's works. The tests made, it is said, showed conclusively that smoke can, in the case of steam boilers, be prevented by various appliances, and with considerable economy in the consumption of fuel. Mr. B. M. Fletcher, of Westminster, who conducted the tests, states as regards the first two trials that the appliance tested being of simple construction and automatic, showed itself to be a successful means of raising boiler efficiency without smoke, and that it can be used by a comparatively careless and ignorant stoker.

Combined Arc Lamp and Post.—A novel kind of arc lamp has been constructed by Rudolph Hunter, of Philadelphia, for the General Electric Company. The

object is to reduce the weight of the lamp to the least possible amount, so as to allow the use of a light and graceful pole. This is accomplished by putting all the heavy regulating mechanism of the lamp inside the top of the pole and not in the lamp proper at all. The lamp is connected to the regulating gear by a fine wire, and itself contains nothing but the carbon-holders and means to feed the carbons. The projecting arm which carries the lamp is jointed, and can be lowered for cleaning and refiling the lamp. This lamp is illustrated in the *Electrical World* (July 8), where it is stated that the combined post and lamp has been exhibited in Philadelphia with entire success. The pole is of hollow metal; the whole is of very light construction, and is meant to supersede the ungainly structures now so often met with in street-lighting by arc lamps.

A Royal Societies' Club.—Under the title of the Royal Societies' Club, a club is being formed which will have for its chief aim the bringing together of members of the Royal and learned societies under the usual conditions of club life, affording opportunities of social *réunion* for the class of members to which the new club will specially appeal. The membership is to be limited exclusively to presidents, members of council, fellows and members of the principal Royal and learned societies of the United Kingdom, India, and the Colonies, academicians and associates of the Royal Academies, together with the presidents, members of convocation, and professors of the universities and various Royal institutions. Premises comprising the whole of the block 63, St. James's-street have been secured for the club-house, which, it is expected, will be ready for occupation early in October. A special feature of the club will be an extensive lecture-room available for the use of the societies embraced in the constitution of the club, or members thereof, for holding meetings. The temporary offices are 8, Waterloo-place, Pall-mall, S.W.

Goebel Lamps.—The Goebel lamp case is proceeding merrily in the Milwaukee Courts with all the concomitants of the stiffest legal fights. Affidavits of the strongest kind abound—those on Goebel's side alone now numbers upwards of 250; accusations of absolute misrepresentation, fraud, bribery, and perjury are common incidents. The Columbia Company have issued a splendid portrait of the old man, meant to produce a favourable impression. Mr. Clarence Seward alleges that the glass tubing out of which the famous Goebel lamps were made was purchased on September 28, 1892; that lamp No. 4 was made by Aug. Hyer at 468, Grand-street, New York; that Goebel only showed oil lamps on his telescope; and that most of the affidavits were signed without knowledge of the contents. Max Hoffmann, a saloon-keeper, testified that Goebel, junior, had said: "That is a nice kind of a judge; if he had dropped on Nos. 1, 2, and 3, instead of 4, he would be nearer hitting the nail on the head. I made those lamps." On Goebel's side, Mr. J. E. Brill testified he had seen the lamps or others like them in Goebel's shop in 1890. Henry Goebel, jun., testified that Max Hoffmann had tried to bribe him to go on the other side for 20,000dol., and go out of the country with a permanent position in the company; that he had led Hoffmann on, to see what he would say, and then went immediately to relate the conversation to Mr. Kenyon, the counsel. The judge's decision in this interesting case was expected by the 17th inst., but we have not yet had particulars.

A Loud Telephone.—A loud-speaking telephone has been devised by Mr. Graham, of the Electric Wiring and Fittings Company, 2, Princes-street, Westminster. In this case, the usual induction coil has been discarded, and the two instruments, transmitter and receiver, are directly connected in circuit with the line and the battery. The transmitter of A at one end of the line is connected to the receiver of B at the other end. As this arrangement only permits of A speaking to B, and not of B replying to A without a change of the connections and a substitution of apparatus, two separate lines are employed having a common return wire. On the second line the transmitter of B is directly connected to the receiver of A. The two correspondents can thus talk quite freely with each other, and as the receivers speak out so as to be heard in any part of a room conversation can be carried on by each person simply speaking to his transmitter. This apparatus is attached to flexible conductors and is held in the hand. To open a conversation it is sufficient to pick up the portable transmitter and press a button in its casing so as to establish the circuit, then speak into it. The receiver at the other end acts as its own call-bell by the loudness of its voice, and the response comes equally prompt and loud. The user has, therefore, no need to listen carefully with one or two receivers held up to his head. All he has to do is speak into his transmitter and keep his ears open. The apparatus is chiefly intended for domestic service from one part to another of a house, office, or workshop.

Storage Battery Tests.—An exhaustive and elaborate report by Profs. John W. Langley and Chas. T. Mabery is published on the Ford-Washburn storage cell, in which its electrical, chemical, and mechanical properties are thoroughly considered. As a result of the test the following conclusions are given: (1) The cells have not appreciably changed their internal resistance during two months' constant use, when tested under similar conditions. (2) Vibration and shaking, continued for an aggregate of 422 hours, did not increase the internal resistance. (3) The ampere capacity of the cells is 150 hours when tested to exhaustion, and when drawn down to one volt a cell holds 133 ampere hours at a 10-ampere rate of discharge. (4) The practical working limits of voltage are from two volts to one volt. (5) The cells do not show any marked tendency to sulphating, and their internal resistance is not permanently raised thereby. (6) During the interval covered by this report neither large rates of charging and discharging nor a prolonged course of vibration, imitating that of a street car, produces any measurable deterioration of plates. In this respect the Ford-Washburn cell was in marked contrast to a cell of the grid type used for comparison. (7) The ampere efficiency varied from 73 to 86 per cent., and the energy efficiency from 55 to 72 per cent. (8) The electrical and mechanical hard treatment to which the cells were subjected in their handling was excessive, and indicates that they have the qualities to withstand rough usage in practice. No measurable impairment of them was developed by exceptionally severe electrical and mechanical usage during two months.

Electro-optics.—M. Basset has published in *La Nature* an interesting review of the situation of the present knowledge of electro-optics. The author describes the action of the electromagnetic field upon light as one of the most attractive branches of optics. He divides the discoveries made up to the present into four groups: (1) The experiments of Faraday, showing that when a beam of polarised light is transmitted across a magnetised medium space, a rotation of the plane of polarisation is produced; (2) the experiments of Kerr, showing that the action of electrostatic force on a transparent medium consists in converting it into a medium optically equivalent to a crystal with single axis, this axis being in the direction of the face; (3) experiments of Kerr on the reflection of polarised light on the surface of a reflector of magnetised iron, show-

ing that a rotation of the plane of polarisation of the light reflected is produced, this rotation being in certain cases in the same direction, and in others in the opposite direction of the amperian current, which may be conceived as producing the magnetic force; (4) experiments of Kundt on the reflection of light by iron, cobalt, or nickel when magnetised, and also on the transmission of light through thin magnetised slices of this metal. Although Hall's effect seems to be intimately connected to the action of a magnetic field or light, this connection is not yet established beyond contradiction. After having discussed the conclusions which may be drawn from Kerr's experiments on the effect of electrostatic force, M. Basset indicates the following experiments as being yet required: (1) Experiments on the reflection of light by a transparent magnetised medium — such as glass, perchloride iron, and also, if possible, liquid oxygen; (2) experiments on reflection by magnetised metals and on the transmission of light through these metals, special attention being given to the effects produced by the non-luminous parts of the spectrum; (3) experiments on reflection by electrified metallic reflectors.

Ship Electric Lights.—In the course of a paper on "Ship Lights and Collisions," read last week before the Maritime Congress, Mr. J. Kenward pointed out the disabilities attending the use of many white masthead and anchor lights and coloured lights of similar construction. He said that he had always advocated the common increase in power of all the lights, and the use of an illuminant in the coloured side-lights as would nullify the reduction of power through colour, and so render the emerging beams of all the lights approximately equal in intensity. In this way the three lights of a moving steam vessel, or the two lights of a moving sailing vessel, may be seen at the maximum distance possible to their position and elevation, and may afford an unmistakable signal of the course the vessel is keeping. He said that electricity was the only convenient means to effect this, and he had arranged some years ago an incandescent lamp of about 100 c.p. for the red light, and another of about 200 c.p. for the green light, together with, for the latter, a particular tint of green glass, which had since been adopted as a standard by the Board of Trade. In this condition, the side-light beams were equal in intensity with the masthead beam. The "Roslin Castle," of the Castle Line of Sir Donald Currie, was the first to adopt this plan of equal lights. It had been quite successful there, though the earlier forms of the apparatus had been much improved since 1884, when he first publicly urged the plan. There was at present an abundance of electric lighting on board the finest ships, and in the case of a few it had been applied to the side lights, but not for the most part in the best manner, or with any reference to equality of beam. There was no longer any official objection to electric side lights, and it might be confidently predicted that in a few years electricity would displace every other illuminant for ship lights, and even for land lights, because its surpassing power could be combined with a largely reduced size of apparatus, and with a striking economy of cost per unit of light.

Blackening of Lamps.—We mentioned the other week Prof. Elihu Thomson's ideas on the volatilisation of carbons. Further details of his views, from a paper on "The Life of Incandescent Lamps," will be interesting. He says that carbon is as yet the best material for that purpose known, and is so from its infusibility and volatility. It actually does soften at extremely high temperatures, and will bend readily when so softened. It does not melt at the highest known temperature, but it readily vapourises in the arc lamp. It is very probable that carbon, infusible as it seems, could be fused at arc temperatures while under pressure. Thus, an electric arc in an inert gas at high pressure would probably drip melted carbon, which would form graphite in masses or crystals. The deterioration of incandescent lamps has often been laid to the bombardment of gas molecules, but Prof. Thomson has long been convinced that in a well-exhausted lamp it is due almost entirely to evaporation by high temperature. Just as ice evaporates in vacuo, so carbon acquires in vacuo a certain volatility at an increasing rate of the temperature. He assumes that the vacuum is so good that none of the visible discharge of current takes place, which of course wears the filament by actual carriage of carbon. He thinks that it would be very strange if carbon maintained at so high a temperature in a vacuum did not evaporate at all, as it is well known that almost all substances raised to a sufficiently high temperature do give off insensible vapours, and that melted metals frequently behave as mercury does at the ordinary temperature; the presence of foreign substances and gases will in some instances accelerate the action and in others retard it. A certain evaporation takes place independent of the size of the bulb, from which it follows that the age-coating will be less as the size of bulb increases, as the deposit will be thinner over a large surface. If two lamps were made, one with the smallest possible bulb, and the other with a large bulb, the former would be opaque when the latter would be only slightly darkened. Great stress is laid on the uniformity of the filament. It appears true, he says, that the limit of practical improvement in the efficiency of incandescent lamps is found in the properties of the element carbon, and particularly its volatility. No other less volatile substance has yet been found, and carbon as pure and perfect in structure as possible is likely to hold its place, at least for some time to come, as the material for incandescent lamps.

Electric Beacons.—A paper by M. D. Lo. Galto, of Naples, was presented last week before the fourth section of the Maritime Congress, dealing with harbour lights, light buoys, and beacons in Italy. As far as electric beacons were concerned, the author said that enquiries into the subject had recently been made at Naples. It was found that with the exception of the light installed in 1884 on the Las Puercas reef in the Bay of Cadiz, no similar lights were at present in use in Europe. In this case the illuminating power is supplied by two six-cell Daniell batteries, and the incandescent lamp is only of 1 c.p. — *i.e.*, 4 volts × 1 ampere = 4 watts. The author said that the disadvantages of this beacon were the very low intensity of the lamp and the employment of a clockwork apparatus working for a considerable time. It was, of course, true that the optical apparatus might develop a high coefficient, but in any case the intensity of this small light on the horizontal plane could never be very conspicuous; and although under the special circumstances, where it requires to be seen only from a short distance, it might be sufficiently suitable, it is too feeble a light for ordinary purposes. With regard to the clockwork mechanism, this might certainly work with regularity for some time, but it could not, with the most perfect workmanship and careful maintenance, be looked upon as really reliable, and any interruption of the action in the Las Puercas beacon would at once cause the light to be extinguished. The Harbour Works Department at Naples had been desirous of studying a 3 c.p. lamp, and they made some experiments with a sixth-order light on the head of the San Vincenzo pier, so as to test the optical result. This was sufficiently satisfactory to make it probable that the combination of a sixth-order lantern with a Swan lamp of 12 volts and one ampere would in many cases

be a sufficiently effective danger signal; but this optical result was deprived of much of its importance by the question of renewals of the batteries. The author concluded that for the present the electric lighting of beacons with self-contained generators of the energy required possessed no special advantages; and that since such excellent results were attained by Pintsch's light, the electric light might be set aside so far as these objects are concerned. In some cases electric lighting might be practicable by conveying the current by cable from the shore; but the system would, according to the author, be very costly, and would involve greater precautions in protection of each end of the cable than might be justified by the object.

Commercial Production of Ozone.—The value of ozone as a deodoriser and disinfectant is well known, and it is conceded by all who are familiar with its character that it is capable of rendering many valuable services, not only for therapeutic or sanitary purposes, but in chemistry and in several industrial processes. The difficulty, however, has hitherto been the economical production of this valuable agent on a commercial scale. The subject has for many years past formed the study of most of the leading chemists of this and other countries. Bunsen years ago pointed out that there were hundreds of uses for ozone if only it could be made in large quantities at a low price, while Faraday, in 1851, in a lecture before the Royal Society, pointed out a number of useful results attending its use, and affirmed it to be a most ready and powerful oxidiser. The late Dr. Werner Siemens appears to have been the first, in 1857, to construct an electrical ozonising tube, and he has been followed by Von Babo, Beanes, Ladd, and many others. The practical results, however, appear to have been but limited, and the only outcome, so far as we are aware, is the production of small quantities of ozone in closed tubes, and its limited use in some of the hospitals on the Continent. Among others who have long and closely followed up this question is M. Emile Andreoli, whose researches have led to the perfecting by him of a system of producing ozone on a practically commercial scale with, it is stated, marked economy. In this process, which is in operation at Messrs. Allen and Hanbury's works at Bethnal Green, metallic open ozonisers are used, in contradistinction to the closed and delicately constructed glass apparatus hitherto employed. An alternating current is produced by a dynamo, and is conducted to a transformer which converts it from the ordinary pressure of, say, 100 volts to 8,000 or 10,000 volts. This high-tension current is conducted to metallic electrodes, which are constructed with thousands of points, and a condenser charge is obtained by means of which the oxygen around the points is condensed or ozonised. M. Andreoli found, says the *Times*, that ozone was generated in far larger quantities by means of point-bearing electrodes than when the electrodes are flat surfaces on which the tension is weak and uniform. The electric tension is at its maximum when there are sharp points from which the discharge escapes, so to speak, in a continuous flow. In one form of ozoniser he uses a series of metallic tapes of small section—each edge of which is serrated like a saw, the tapes being strung, gridiron fashion, in a frame. The points give a much higher percentage of oxygen ozonised, a full 5 per cent. of the oxygen of the air being ozonised, it is stated, at the ordinary temperature, and under ordinary conditions by M. Andreoli's apparatus. Other forms of ozonisers are employed for particular purposes.

Electricity in Gas-Pipes.—The piercing of gas-pipes at Paris electrically has given rise to much heart-searching on the part of both electrical and gas companies. An accident which occurred on March 2, 1891, in the restaurant Larue was a clear instance of short circuit—a kind of case that does not occur frequently. High-tension mains were led into a service box at 2,500 and 1,800 volts—the first for public lighting and the latter for charging accumulators—low tension mains at 110 volts for private lighting also were jointed at the box, and one of these touched a gas-pipe. The workmen, instead of advising the gas company, had built the gas pipe into the brickwork, and by some means a short circuit had occurred, piercing some crater-like holes in the pipe, and an explosion occurred. It did not seem that there was actually contact; a little water intervening affording the necessary resistant path to give off sufficient heat to melt the lead. The accident in the rue Notre Dame de Lorette (June 5, 1892) was apparently due to electrolysis. Two box covers were blown into the air, knocking a woman over. They were replaced, but twice after were blown up again the same evening. The explanation given is as follows: The subsoil in Paris is calcareous or sulphated broken material. When a leakage of electricity occurs, the current returns by the gas-pipes, passing through the surrounding soil, forming to this extent an electrolytic bath—cable and gas pipe being the two electrodes, and the soil, impregnated with water often slightly acid, being the electrolyte. Experience shows this to be the case. When a leakage is sought, its presence is accompanied by heating of the surrounding soil, the gas-pipe is electrified, and in the surrounding calcareous soil the lead of the pipes is covered with a powdery layer of carbonate and hydro-carbonate of lead mixed with oxide of lead. This formation of carbonate and oxide causes thinning of the pipe and eventual perforation. The Edison Company since the accident at the corner of the rue Bréda have replaced their conduits of glazed earthenware by cement conduits on the Clerc system, which, it is stated, are more gas-proof; all which goes to prove that special precautions must be taken for the prevention of accidents of this nature. The commission instituted by the decrees of 1884 and 1885 had prepared rules for laying mains, but had made no mention of gas-piping, save to say it was not to be used as a return for electric mains. After the Larue explosion a new commission was instituted which drew up regulations dealing with the following points: (1) Kind of insulation for cables in metallic coverings; (2) insulation of said cables as regards other mains—gas, water, compressed air, etc.; (3) absolute prohibition of inclusion in any manhole for electric mains the pipes of any other service; (4) the arrangement of pipes and conductors in these manholes; (5) obligation to notify the other companies when coming across their mains; (6) obligation to thoroughly test every detail of the electric network at least once a year. The recommendations of the commission are embodied in carefully drawn up regulations carried out under the control of the municipal service engineers. The companies interested are heartily co-operating to prevent the recurrence of accidents.

A New Boiler-Flue Cover.—The usual practice with boilers of the Lancashire and Cornish horizontal type of covering in the side and end flues with curved flue covers, and surmounting them with several inches, say, 9in. to 18in., of brickwork, is not a very economical or advantageous method in the long run. For instance, when it is desired to inspect the boiler or clean the flues, it is found to be an expensive matter to remove the covering over the tops of the flues, and the consequence is that it is rarely removed and replaced. The results of this are that the operations of cleaning and inspection have to be conducted in the dark,

the flues do not get properly cool, and there is loss of time in allowing them to cool sufficiently to permit a man to enter them, whilst at the same time the working water-line outside the plates cannot be examined without taking off the brickwork. Besides these there are other disadvantages, one being the great expense necessary in case of a thorough examination of the boiler being required. Mr. G. C. Taylor, of Helsby, near Warrington, has, however, devised a flue cover and composition which overcome these difficulties. The arrangement consists in building up the brickwork straight up to where the flue cover is to rest, and right round the back and side of the side and back flues. As the thickness of the flue cover and composition is only about 4in., or more if necessary, the flue can generally be raised up 6in. higher and still be under the water-line with safety. This method therefore gives one square foot more flue heating surface per foot in length and around the back of the boiler. With a 30ft. by 7ft. boiler this arrangement affords an extra heating surface of about 32 square feet. Over the top of the boiler, but not in contact with it, are arranged saddle-irons, which are carried down just below the top of the brickwork; at their lower ends the saddle-irons carry a longitudinal tee-bar, attached to them by an iron pin, and which, together with the brickwork, supports the flat iron flue cover, which is surmounted by the composition, making a tight joint. A compensating screw bolt is provided to move or level the saddle-irons, and as the latter are not attached to the boiler in any way, and as the flue cover is not connected with it, the boiler is free to expand without a mass of brickwork resting upon it. This type of flue cover was, in November last, fitted to a 22ft. by 7ft. Lancashire boiler at the works of the Telegraph Manufacturing Company, Limited, at Helsby. In this case two side flues and one back flue were uncovered, the soot removed, and the Taylor flue covers and composition substituted, the whole of the work being accomplished and the boiler ready for firing up in about three hours at a cost for labour of 2s. 6d. After six months' working, the ironwork of the flue covers was found to be in an excellent condition, and no deterioration was perceptible. The same company have had another boiler similarly equipped. Among the advantages claimed for this system may be mentioned that the flues can be opened and any part of the boiler examined and the flue covers replaced in less than half-an-hour; that when the covers are removed the whole of the side and end flues are open and the boiler exposed to daylight; that the flues cool down in half the time if opened, thus saving time on inspection and cleaning; that any leakage is more readily discovered and rendered accessible; that the composition is a non-conductor and can be reused at small expense, and is free from acid or anything likely to injure the boiler; and that the increased heating surface afforded by the system, and the more frequent cleaning of the flues, result in a saving of fuel and an increased horse-power obtainable from the boiler.

Electrophysiology.—Some further particulars are to hand with regard to the experiments by M. Leduc on alternating electrostatic currents. When an electrostatic machine is worked and a series of sparks apparently continuous pass between the knobs, the conductors are, as is well known, subject to variations of potential—in fact, to electric vibration. These vibrations are utilised by M. Leduc to produce other alternating or vibratory currents. If a Leyden jar is suspended by a rod from its inner coating to each of the conductors of the machine, and the external coatings of the two jars are connected by a high-resistance circuit, the internal coatings become part of the conductors. Electric vibrations of reverse nature take place at the same instant of time on the two inner coatings, one rising as the other falls, and the vibration is communicated to the outer coatings, so that on the circuit connecting them a vibratory current is set up. The resistance between the outer coatings should be such that the total capacity of the Leyden jars is proportioned to the output of the machine. If, for instance, the two coatings are connected by a circuit of negligible resistance, the conductors (of which the coatings form part) having too large a capacity, the sparks become intermittent, and a vibratory current in the true sense of the word is not obtained. But with a high resistance between the external coating, oscillatory discharges could not be produced between these coatings. The experiments were carried out with a Wimshurst machine having two glass plates 2ft. diameter. The vibratory currents obtained by the means of electrostatic machines have properties similar to but not identical with those used by Mr. Tesla. Conductors carrying these currents become luminous, and, under good experimental conditions, give from their whole surface brushlike discharges differing much in intensity and other characteristics from those of electrostatic electricity. By varying that form of the conductors and by bringing other conductors near, very varying and very beautiful luminous effects are produced. The best arrangement to carry out this experiment consists in putting one of the external coatings to earth and connecting the other with a hanging chain in contact by a point with the base of the machine. If the hanging chain of the preceding experiment is covered with an indiarubber tube, and this tube is taken in the hand, it becomes luminous as if phosphorescent by the production of short brush discharges, in the form of an aura between the hand and the tube; the sensation is not painful. If a Tesla tube is brought near to the free conductor, it lights up at a considerable distance away, and if the balls of the exciters are separated so as to suppress the alternations while increasing the tension, the tube becomes dark, and must be brought much nearer to light up again. An incandescent lamp bulb suspended on the free conductor becomes luminous, and its luminosity increases if touched. This lamp and the indiarubber tube itself are both strongly attracted by a conductor in communication with earth — by the hand, for instance. The same experiment made with static electricity gives an attraction followed by a repulsion, while with these vibratory currents only attraction is produced. These high-tension alternating currents obtained with static machines are noticed to have, as we have already mentioned, a great effect on the sensory and motor nerves. One electrode is sufficient. A blunt metallic point is used, mounted on a glass handle, attached to the free chain of one of the external coatings; this point moved over the skin, when passing a motor or sensor nerve, excites the nerve throughout its whole distribution beneath the electrode. The sensation throughout the region covered by the nerve is so plain that it allows the distribution to be mapped out. MM. Pellat, Gariel, and D'Arsonval verified these experiments of M. Leduc. But the experiment which caused the most interest and surprise was the production of muscular contraction at a distance by the aid of currents themselves produced in the human body by induction. The observer being placed between the machine and a live frog, if he moves his hand near to the frog as if to point at it with his forefinger, even at the distance of so much as a yard away, the muscles begin to contract. If the hand is moved nearer or farther away, these movements are inscribed on the myograph by this new kind of galvanoscope.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

ARC LIGHTING.

(Continued from page 56.)

Town Lighting.—The greatest field for arc lighting is undoubtedly that of the illumination of the streets and public thoroughfares of towns, and now that some of our most important cities are having central stations put down, there is great prospect that the dull, miserable gas lights will quickly disappear, to make room for the brilliant light of the electric arc. Nobody can fail to mark the great contrast presented when passing from a district lighted by arcs into one lighted by gas—the latter in comparison with the former is a region of gloom. In England it is very seldom that one comes across a town that is decently lighted by gas, and even then it is confined to the few important streets, but the progressive spirit of the age and the mode of life in this nineteenth century demand what Goethe in his dying moments vainly sought for. "Light; more light!" was the cry of that giant of intellect, and as his wonderful mind groped in the dark, so do we, in a physical sense. It is the effect of the contrast between gas and electric lighting that will do more to further the adoption of the latter than anything else. People that visit a town brilliantly lighted by the new illuminant will feel the gloom and semi-darkness of their own gas lighted town in a tenfold degree, for when a higher standard is reached, no matter in what, the old one is dwarfed in value, and as the gas flame supplanted the rushlight in its lighting powers, so will the electric light supplant gas light. Next to drainage, one of the very greatest blessings a town can have is good light and plenty of it; not merely for personal convenience in getting about in the streets, but for the whole welfare and improvement of the place. The town will score a decided advantage over its ill lighted neighbours, business is brisker, the vehicular traffic is rendered safer and more expeditious, and the general tone of the place is raised. A brightly-lighted town tends to make the inhabitants more cheerful and smart. Ill-lighted towns drive away trade and visitors, throw a despondency over all, and nurse crime as darkness does noxious plants.

In the majority of English towns the central part consists of narrow, tortuous streets huddled together, forming the old nucleus of the town, and where the town is one that has opened out and improved, wider and straighter roads will radiate out from this centre. When going into the matter of lighting a town by means of arc lamps, the plan of the town must be very carefully analysed and studied, and it is no use trying to find a precedent: each town must be considered and judged from its own advantages and disadvantages. No two are alike: each has its own local peculiarities; and every street, every square, must be thoroughly considered with regard to amount of traffic, public buildings, most suitable distribution of light, and such like details, so that the engineer must identify himself with the requirements of the town as if he were an inhabitant, and so had to participate in the lighting arrangements he is about to introduce. Planned-out roads, fairly straight, or with gentle curves, are easy enough to light; it is the rabbit-warren collection of streets that cause trouble, for light will not go round a corner, and since arc lamps are placed much farther apart than gas lamps are, it becomes difficult to light up a street that bends about. In these cases, it is perhaps best to employ arcs of small candle-power, so that they can be placed nearer together than what larger-sized lamps would be; then in the straight roads these large lamps, well apart, can be positioned where their full light will be utilised. Small and side streets, alleys, etc., are best lighted by incandescent lamps -16 c.p. or 32 c.p., according to the amount of light deemed necessary; lamps of 8 c.p. are of little use, being too feeble, and they should never be used for street-lighting. Incandescent lamps can easily be run off an arc lighting plant, and the combination of the two, judiciously placed, provide a flexible and satisfactory way of dealing with all the streets of a town, from the main thoroughfares down to the insignificant side street.

Full details of such systems will be given when the subject of distribution of electricity is reached. The positions of the gas lamps indicate best where the light is mostly wanted; they will also indicate by their distance apart the relative degree of light required in various parts of the town, so that although they do not illuminate well, they provide a good guide as to how the light should be distributed. The great art in fixing arc lamps in the streets is to always have one at a corner or junction of roads, and erected in such a position that, whether there be three or four or more roads meeting at that point, the light from the arc shall penetrate down all the roads or streets. It is at such corners and junctions that the use of the arc is shown, since the number of gas lamps which one arc will displace will increase with the number of roads which the arc commands. Suppose one arc will illuminate as far as three gas lamps at a certain distance apart, then one arc will displace three gas lamps along a straight road, and at three cross roads will displace five gas lamps, and at four cross roads as many as seven.

In small country towns, very little traffic is in the streets after 10 p.m., and most of the inhabitants are indoors, and towards midnight scarcely a solitary person is about, so that at that time one-half of the arc lamps could easily be dispensed with and switched off. This would effect a considerable saving, for in addition to the decrease of the current, and the saving of electric energy, the consumption of carbons in the lamps is reduced probably to one-half, and the lamps will require less trimming, thereby saving the trimmers' time. The incandescent lamps could not very well be diminished, being small lights, they would all be required. In the United States, when a town enters into a contract with the electric company located there to light the place with arc lamps, the moon schedule is always brought in; this means that whenever there is a full moon visible and an unclouded sky, the arcs can be switched off, since the moon supplies ample light: for every night on which the moon lights the town instead of arcs so much is taken off the contract price. The same might be done in England, but at much greater risk, because there is no knowing how the weather may change.

Where the roads are wide and the traffic permits it, the best position for the arc posts is in the centre of the road: the light is then distributed equally on each side. In the majority of places, however, it will be found that they must be placed along the kerbstone, like gas lamps, and fixed alternately on the right and left side of the road. When arc lighting was first introduced into the streets, wooden poles with a slight taper and painted dark green were used, the height being about 30ft. Now that the lighting is a proved success, it is better to erect more substantial ones in the form of light steel tubular poles or cast-iron ornamental standards. The arc lamp can be fixed on the top of the standard, or it can be hung from a bracket arrangement; this latter way is useful when the lamp is at a street corner, since it can be projected over the roadway. Chelmsford, in Essex, was the second town in England to have its streets entirely lighted by electricity, arc lamps being used for the main thoroughfares, and 32-c.p. incandescent lamps for the rest. The main artery of the town is about a mile long, and takes a right-angled course; there are 20 arcs, and therefore 20 arcs to the mile. This gives an average distance apart of 88 yards, or 264ft. In the central portion of the route they are fixed 70 to 80 yards apart, further away the distances increase to 120 to 130 yards apart. The height of these arcs is 30ft.; the writer does not know their actual candle-power.

Until lately there was no arc lamp that would burn satisfactorily with alternating currents, and there are now very few in the market that are of any use, so that there is an unexplored field open for the adaption of arc lamps for alternating currents. Since an alternating current flows first in one direction and then in another, therefore the carbon tips both become somewhat pointed, and no crater is formed on either, consequently as much light is thrown upwards as is thrown downwards, a very different case to arc lamps run with continuous currents. These upward rays are therefore wasted in street-lighting, so that small

reflectors should be provided fixed over the arc, thus throwing the upward rays towards the ground.

There is very little reliable data concerning a comparison between an alternating current arc and a direct-current arc. Some say the former gives more light than the latter for the same amount of power. There is certainly a great future before a good alternating-current arc lamp, particularly one that is adapted for running in parallel across the secondary of a high-tension alternating-current system, such as is mostly used for distributing electricity over wide areas. One curious thing about these lamps is that they emit a humming sound when burning. The cause of this is not known. It may be due to the alternate rapid heating and cooling of the carbons, promoted by the continual change of polarity.

(To be continued.)

PROPOSED ELECTRIC UNDERGROUND RAILWAY FOR BRUSSELS.

More than one proposal has been made before now to give the Belgian capital a complete and satisfactory system of rapid transit; indeed, we might almost say that if all the suggestions that have been made could be carried into effect, the Bruxellois would have nothing to do but ride about the city all day long in an overwhelming variety of vehicles—underground, above ground, and even in the air!

Not the least important of these schemes, however, is that based upon the Greathead system of deep tunnels, 50ft. or so beneath the ground-level; and the very fact of Brussels being by nature a city of hills should give such a plan the more weight because of its entire independence of surface profile. An electric line of any kind on the ordinary ground-level, and even an elevated railway, would without doubt find serious obstacles in the heavy grades to be encountered; the tramcars now running, for instance, often require three and even four horses to deal at all adequately with the traffic, whilst the speed attained is trifling compared with what could be given by any good mechanical system.

In *La Nouvelliste* of Verviers, under date of July 23, appears a large illustrated supplement dealing with this proposal, and giving the details necessary for the general public to understand such technicalities as appear essential to the scheme.

This "Projet de Chemin de fer Electrique Souterrain" is due almost entirely to the initiative of Mons. Alph. Mullender, the United States Vice-Consul for the province of Liége, and a merchant in a large way of business at Verviers.

Mons. Mullender applied at the end of last year to the Minister of Public Works for a concession which will enable this line to be undertaken and built, and the scheme now submitted embodies not only a complete plan for Brussels, but also shows what has been done elsewhere in a similar direction—notably with regard to the City and South London Railway. Although, as already stated, Brussels is by no mean without means of transit, these are looked upon as insufficient for modern requirements; what the inhabitants now call for is a service at once more rapid, more regular, and more frequent than the street tramways can possibly give. Brussels, by the way, is not singular in this respect; but let that pass. The tramway company of Brussels already carries more than 16 million passengers per annum; but this does not, it is said, represent in the least the possibilities of passenger traffic, for the reasons given. Some details of the tramway system will be of interest in this connection. With a capital of 15 million francs, a length of line equal to about 35 kilometres, rolling-stock to the extent of 108 cars, worked by 696 horses, the total receipts for the first six months of the present year reached the sum of 1½ million francs. The proportion of expenses to receipts is, however, as high as 76 per cent., owing, very largely, to the steep grades and heavy cost of working them.

Mons. Mullender, in his proposed underground system, expects not so much to enter into competition with the surface tramways as to supplement their efforts by giving methods of transit quite out of their power, but which are urgently required by the public. According to the new scheme, 11 stations would be available on the circle first constructed. The entire plan, it should be said, comprises practically one complete circle of course, with double lines—a second circle branching out from the first, following afterwards as an extension.

The length of line proposed at the outset amounts to some 6,140 metres, or, say, four miles. As in the South London line, the tunnels would be quite distinct from one another, hence avoiding all danger of accidents or stoppage of traffic between line and line.

The minimum curve radius is about three chains. The tunnels, almost without exception, would run throughout the whole of their length below the public streets; and their depth would be sufficient to ensure reliable strata in which to work. For the greater part the subsoil appears to be clay, so that a use may be found for the excavated material.

It is proposed to build the generating station on a site outside the first circle, and therefore some distance from the extension; but, of course, in a crowded city the most convenient place for a supply station is not always the cheapest, either in first cost or in daily working. The power available would, however, serve to give a 2½-minute service each way from 6 a.m. to midnight, a double staff of men being employed on a nine hour shift. It is doubtless to be expected that as a counter-balancing disadvantage the wages to be paid for this work would be less than are current in this country; otherwise a rush of labour might take place towards Belgium pending an eight-hour day over here.

The second circle—or extension of that first proposed—has four stations only on its entire length of 3,430 metres, or, say, nearly two miles. That part of the city through which this line would run is by no means well provided with rapid transit, and it is therefore expected that no little increase of revenue would result from completion of the whole plan.

The total cost of the first circle is estimated to require a capital of 17½ million francs, or, say, £700,000—a sum which would, however, only build about three miles of line instead of four, taking as a standard the £200,000 per mile of the South London Railway. The working expenses per annum are estimated at 750,000f. (= £30,000); whilst a sinking fund equal to 886,000f. (£35,000) would bring this up to 1,636,000f. (£65,000). Fares over the whole line for any distance are to be 20 centimes—say, 2d.—second class, and 30 centimes (3d.) first class.

The appearance of the station buildings on the street-level closely resembles that of the ordinary tramway waiting rooms, a short staircase leading down to a large hall beneath the pavement, with ticket office, and entrances to the lifts working up and down to the platforms. The design of these lifts is of the usual type worked by water pressure, and made to contain 40 persons. Of course safety appliances are provided for.

It is hardly worth while going into the estimates of probable working cost and receipts on the proposed line; conclusive proof has been afforded by the South London Railway that an underground electric line can be made to pay if the traffic exists. The financial aspect, however, deserves separate treatment. F. B. L.

THE ACTION OF COMPOUND DYNAMOS WHEN RUN IN PARALLEL.*

BY WILLIAM L. PUFFER, S.B.

(Concluded from page 17.)

There is a very safe and simple method of throwing in a new dynamo, which does not, however, prevent a change in the switchboard voltage unless a special switch is used as shown in Fig. 6, constructed in such a way that the equalising connection is first made and then the outside end of the series coil gradually connected by a switch with a few

* From *Technology Quarterly*, vol. v., No. 4, December, 1892.

resistance points in it, while at the same time the magnetising effect of the shunt coil of the loaded dynamo is increased to make up for the loss in the series coil In this way the series coils can be put in parallel with no jump in the voltage. If, however, there are many similar dynamos in the plant, it might be that the change produced by throwing in a series coil without its armature would not produce a greater change than would be allowable; in such a case the safest way is to connect first the series coils, then rapidly adjust the armature voltage by the voltmeter, or, if in a great hurry, by the looks of the pilot lamps, and then close the armature switch, well knowing that the steep net falling characteristic of the armature circuit will prevent an overload.

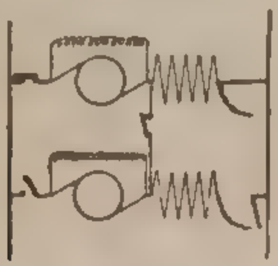


FIG. 6.

The common three-pole switch generally used can easily be changed so as to admit of working in this way by cutting through the top of the insulating bushing and putting a separate handle on the blade which closes the armature lead to the 'bus wire; then pulling the ordinary handle out will open all blades at once, but pushing it in will only connect the series coils, leaving the armature circuit open. If the wiring is so that the series coils are permanently connected and a new dynamo is thrown in by a single-pole switch, we have here a very wide range of voltages for the new dynamo, and pilot lamps may be used to judge the voltage. We have two 'bus bars with all the series coils joined between them; evidently, then, the total current flowing from bar to bar will simply divide between those coils inversely as their respective resistances, and we shall, in consequence, have the voltage of the armature 'bus bars rising and falling with the total current from the plant; and if the machines are similar all of the armature voltages will rise and fall together. If this is so, and it cannot be otherwise, these armatures are to be considered simply as net falling characteristic armatures working in parallel between the equalising bar and the third 'bus bar, and the division of the load between them will take place exactly as has been previously shown for common shunt dynamos, and therefore, inasmuch as we have a very decided net falling characteristic, there is but little danger of an overload on a new dynamo armature.

FIG. 7.

It is now clear that when we wish such dynamos to run together we must first adjust the resistances of all the series coils and connections, so that when a current is passing through them but not through the armatures, the armature voltages must be equally affected; and also see that the armature circuits are so arranged as to give the same net falling characteristics independent of the series coils. It is necessary for good compounding to have the brushes set once for all, and in all well designed dynamos it is possible to find a point where there will be no excessive sparking. An easier although not so good a way to adjust is to find the best point for the lead, and then alter the resistances of the series coils until all dynamos have the same net characteristics; but the rise of voltage due simply to the flow through all the series coils will in this case be different in different dynamos, and there will be a little more difficulty in adding a new dynamo, and a tendency to overload.

Nearly all of the compound dynamos in the market for the last few years are purposely built with too many turns in the series coil, and then a shunt of German silver is adjusted by trial at the factory until the voltage at the terminals show the wished-for "0 per cent. rise," or whatever it might be Now, for any one dynamo running under the conditions of the experimental trial this method is simple and perfectly correct; but when such dynamos are run together in multiple it is of no service, and has no effect on the relative actions of the series coils of the dynamos, because of the fact that all coils and all shunts become parallel conductors, and therefore traverse by currents inversely proportional to their resistances. These shunts then merely diminish the total flow of current through the series coils, but in no way do they serve to adjust the effect of the series coils relatively to each other. If it should happen that one dynamo was very much over-compounded and then shunted for the "0 per cent. rise," and another only very slightly over-compounded, and consequently only slightly shunted, it is plain that when the shunted series coils are in parallel the shunts will have only the effect of affording a path for a part of the total flow of current, and consequently could be wired up in any convenient place on the switchboard. These two above-mentioned dynamos would then be dissimilar over-compounded machines working in parallel, and in all probability an increasing load would be largely carried by the dynamo with most turns in the series coil, because an increase in total current flowing through the series coils would promote the voltage of this dynamo faster than that of the other. This will be the familiar condition we often see in power plants where the average load is equally divided, while an overload is taken quicker by the dynamo which takes the loss at light loads—that is, the one in which the series coils have greatest effect.

In order to make such dynamos work properly it is best to examine the lead and the wiring, and, if possible, give the armatures similar net falling characteristics, and then, by the use of copper or German-silver ribbon, slightly change the resistance of the series coils until all armatures are equally affected by the flow of current in the series coils, a single large shunt may be connected at any part of the bars to which the series coils are attached, or perhaps better, each machine may have a shunt across the series connections at the switchboard, on the dynamo side of the main three-pole switch, so that the total shunting capacity varies, as it ought, with the number of dynamos running.

After one of my lectures a few weeks ago two young men asked me for an explanation of what seemed to them a very strange phenomenon which always occurred when a large dynamo was cut out of service; and as it is a very good practical example of the use of multiple characteristics as I have shown them, I will give it. In a railroad power-house are about 16 100-h.p. "0 per cent. rise" dynamos, and one large 500-h.p. "0 per cent. rise" dynamo, all provided with shunts. Ordinarily the machines all do well enough, but as the load gets light at night and the big one is cut out the voltage rises instantly about 30 volts in some unexplained manner. May not this be the reason? The series coil and shunt of the large dynamo are of so low resistance that they carry a large part of the total current in all the series coils and shunts. Now, when the machine is to be cut out, the current in the armature is cut down by the rheostat in the shunt field circuit to as nearly as may be nothing; but this current is in this way slowly shifted to the other 16 armatures, causing a slight fall in voltage due to the net falling armature characteristics, which drop is not counteracted by the series coils because there has been no change in the distribution of the total current. This slight fall is probably not especially noticeable, but the sudden jump comes when the series coils and shunt ribbon of the 500 h.p. dynamo are cut out of circuit and the large current in them is instantly transferred to the series coils of the other smaller dynamos. If the switches were made to stand the arcing, I doubt if there would be much change noticed if the dynamos were simply disconnected without gradually diminishing the armature current.

It has been supposed in this paper that there is no such a thing as time required to change the strength of dynamo magnets, and that there is no difference between the

ascending and descending magnetising curve of iron. These time effects will not come in for ordinary fluctuations if the net armature characteristics are similar, and consequently the required changes in all the magnets would be of the same amounts, and would, therefore, take nearly the same time; for sudden changes like a short circuit it is not likely that the load would divide equally, but it would be very much nearer so than with the ordinary unadjusted dynamos, and a heavier short circuit could be burned out than with unadjusted dynamos, where some would rapidly overload and open their circuit breakers and thereby precipitate a general breakdown.

In large plants where more than one dynamo is driven by a single engine and there are several engines, it will be found of advantage to adjust each set of dynamos so that they will work well together, and then adjust each engine load for engine speed change. To do this, each dynamo on a single engine would have its series coil and shunt properly adjusted until, as far as that particular engine load is concerned, the load would be equally divided between the armatures; then the sets of series coils corresponding to the different engines would be connected through a small resistance to the station 'bus bar, and we should find that the total load could be evenly divided between the engines. The arrangement of these resistances is indicated in Fig 7, which shows three engines, each driving three dynamos by belts or any convenient way. The three series coils of each unit are adjusted so that a changing load will be equally shared by each dynamo, and then the three coils are shunted until the desired compounding is attained. It is now necessary to compensate for any difference there

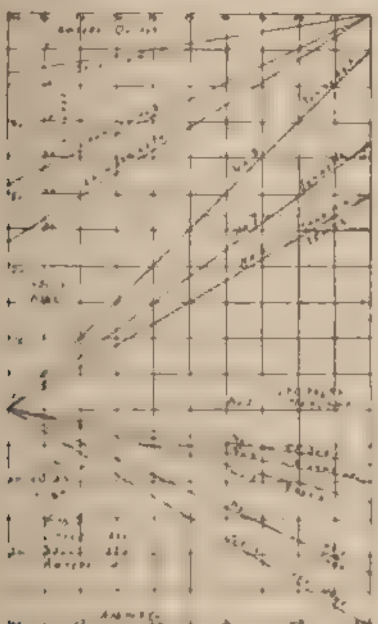


Fig. 8.

may be in the speed regulation of the engines or in the main belt slips by a slight change in the total resistance of the three sets of parallel series coils. There will be, of course, the usual precautions necessary when throwing in or cutting out a set of dynamos, and the most satisfactory way, if steady voltage is to be desired, will be to close the three large main switches at once by steam or other power acting upon heavy switches built to stand the arcing of such currents, thus connecting simultaneously the three 'bus bars to the station main bars; the same method should be used to disconnect when the time comes for stopping an engine.

In order to study the action of dynamos which were exactly similar in all respects, except the magnetising effects of their series coils, a number of turns of wire was wound upon the magnet spools of dynamo No. 2 and connected in series with the regular windings, and the resistance of the series coils of dynamo No. 1 was made equal to that of No. 2 by the addition of a length of copper wire. Each dynamo was then fitted with the usual German-silver shunt of such resistance that the net result was a constant potential at the terminals. The various curves of these dynamos are plotted in Fig. 8, and may be described as follows: Curve 3 gives the fall of potential or drop in volts due simply to the fall in speed as the load on the dynamo increases, and is the same for each separately driven dynamo. Curve 4 gives the drop in volts in the total armature circuit from equaliser wire, which will be considered as a 'bus bar to main 'bus bar, and does not include the drop in the series coils and connection to the 'bus bar which is given separately in curve 5.

Curve 0 is the sum of curves 3, 4, and 5, and represents the total drop in each dynamo when running independently, due to all reactions; while curve 1 is the sum of 3 and 4, or the total drop if we consider the series coil as a part of the external circuit. Curves 7 and 8 show respectively the rise in voltage due to the current in the series coils of each dynamo, and it will be seen that for the same current value dynamo No. 2 has a somewhat more powerful series coil. Curve 6, being the equal and opposite of curve 0, shows the rise in volts which each dynamo must have in order to maintain a constant potential at its terminals; and therefore a horizontal line cutting curve 6, as, for example, at the rated current of 45 amperes, will cut the curves 7 and 8 at points whose corresponding current values are those which will produce the required magnetising force, and the difference between these current values and the rated current must be carried by the shunts on the series coils.

The series coils of each dynamo were adjusted to a resistance of ·15 ohm, and the series coil shunt of dynamo No. 1 had a resistance of about ·60 ohm, and would carry at full load about nine amperes, leaving 36 amperes to produce the rise of 27 volts necessary to neutralise the total drop taken from curve 0. To produce the same rise in No. 2 dynamo required a shunt of about ·22 ohm carrying 18 amperes, leaving but 27 for the series coils.

These two dynamos are now in such a condition that according to the usual practice it would be perfectly proper to run them in parallel with the expectation that everything would work well; however, such is not the case, as may be seen from the curves, and as was proved by the actual effects obtained.

When the two series coils with their shunts are thrown in parallel the total flow of current through them will divide inversely as the resistances of the four circuits, which are, as we have just seen, two series coils each of ·15 ohm, one shunt of ·60 ohm, and one of ·22 ohm. If we call the total current 100, these four circuits will carry respectively about 33·7, 33·7, 8·4, and 24·1, and as the total output of the two armatures may safely be 100 amperes, the above figures give the strength of current in these circuits.

At the top of Fig. 8 is a scale reading from right to left up to 100 amperes, and near the left-hand side a scale reading downwards up to 30 amperes; the three inclined lines enable us to read at once the actual current in the two shunts and the two series coils for any output of the dynamos when running in parallel.

It has already been shown that each dynamo is individually capable of maintaining a constant potential at the 'bus bars independently of the current flowing, and it has been stated that the dynamos will not work well in parallel. Suppose that the dynamos are connected in parallel at 220 volts under no load, and that a current of 90 amperes, which is equal to the rated load of the two dynamos, is taken from the bus bars. To find the currents in the series coils we find under 90 amperes total output that each series coil will carry 30·4 amperes; the shunt on No. 1, 7 6 amperes; and the shunt on No. 3, 21·6 amperes.

No. 1.	No. 2.	
220	220	Volts at no load.
+ 22 5	+ 30 2	Rise from curves 7 and 8 at 30 4 amperes.
242 5	250·2	Total armature voltage.
	− 7 7	Fall of volts due to 17 amperes, curve 1. No. 2 can deliver current producing a fall of 250 2 − 242·5 before No 1 begins to act as a dynamo at all, and after that both armatures will divide the remainder, or 90 − 17 = 73, and the total drop is taken from curve 1 for one half the difference, or 36 5 amperes.
242·5	242 5	
− 16 5	− 16 5	Drop with 36 5 amperes, curve 1.
226 0	226·0	Armature 'bus bar voltage.
6 5	6 5	Drop in the series coil giving for the main 'bus bars 220 5 volts with an output of 36 5 amperes from dynamo No. 1, and 53 5 from No. 2.
220·5	220 5	

As an interesting example of the different degree of badness which may be produced when two individually well-adjusted dynamos are run in parallel, let us suppose that these two dynamos are placed in proper alignment, and one large driving pulley slipped over the ends of the shafts, as is very often done, thus making the armatures run at the same speed with the same per cent. belt slip, which will bring the resultant voltage about the same as in the previous example.

No. 1.	No. 2.	
220	220	Volts at no load.
22·5	+ 30·2	Rise from curves 7 and 8 as before.
242·5	250·2	Total armature voltage.
	- 7·7	Fall of volt due to 38 amperes. Curve 4.
242·5	242·5	Dynamo No. 2 must deliver a current producing a fall of volts equal to the difference of the armature voltages before No. 1 will deliver any current. The remaining current will divide equally, producing a fall found in curve 4.
- 5·2	- 5·2	Fall with 26 amperes. Curve 4.
237·3	237·3	
- 6·5	6·5	Drop in series coils. Curve 5.
230·8	230·8	
- 11·2	11·2	Belt slip. Curve 3.
219·6	219·6	Voltage on main 'bus bars with an output of 26 amperes from dynamo No. 1, and 64 from No. 2.

COMPARATIVE TABLE.

	No. 1. Amperes.	No. 2. Amperes.	Volts.
Separate loads	45	45	220
Parallel	36·5	53·5	220·5
Parallel at same speed	26	64	219·6

ON LIGHT AND OTHER HIGH-FREQUENCY PHENOMENA.*

BY NIKOLA TESLA.

(Continued from page 64.)

As regards the rise of potential through resonant action, of course, theoretically, it may amount to anything, since it depends on self induction and resistance, and since these may have any value. But in practice, one is limited in the selection of these values, and besides these, there are other limiting causes. One may start with, say, 1,000 volts, and raise the E M F to 50 times that value, but one cannot start with 100,000 and raise it to 10 times that value because of the losses in the media, which are great, especially if the frequency is high. It should be possible to start with, for instance, two volts from a high or low frequency circuit of a dynamo and raise the E.M.F. to many hundred times that value. Thus coils of the proper dimensions might be connected each with only one of its ends to the mains from a machine of low E.M F., and though the circuit of the machine would not be closed in the ordinary acceptance of the term, yet the machine might be burned out if a proper resonance effect would be obtained. I have not been able to produce, nor have I observed with currents from the dynamo machine, such great rises of potential. It is possible, if not probable, that with currents obtained from apparatus containing iron the disturbing influence of the latter is the cause that these theoretical possibilities cannot be realised; but if such is the case, I attribute it solely to the hysteresis and Foucault current losses in the core. Generally it was necessary to transform upward, when the E M F. was very low, and usually an ordinary form of induction coil was employed, but sometimes the arrangement illustrated in Fig 20 II. has been found to be convenient. In this case a coil, C, is made in a great many sections, a few of these being used as the primary. In this manner both primary and secondary are adjustable. One end of the coil is connected to the line, L_1, from the alternator, and the other line, L, is connected to the intermediate point of the coil. Such a coil with adjustable primary and secondary will be found also convenient in experiments with the disruptive discharge. When true resonance is obtained, the top of the wave must of course be on the free end of the coil, as for instance, at the terminal of the phosphorescence bulb, B. This is easily recognised by observing the potential of a point on the wire, w, nearer to the coil.

In connection with resonance effects and the problem of transmission of energy over a single conductor which was previously considered, I would say a few words on a subject which constantly fills my thoughts, and which concerns the welfare of all. I mean the transmission of intelligible signals, or perhaps even power to any distance without the use of wires. I am becoming daily more convinced of the practicability of the scheme; and though I know full well that the great majority of scientific men will not believe that such results can be practically and immediately realised, yet I think that all consider the developments in recent years by a number of workers to have been such as to encourage thought and experiment in this direction. My conviction has grown so strong that I no longer look upon this plan of energy or intelligence transmission as a mere theoretical possibility, but as a serious problem in electrical engineering, which must be carried out some day. The idea of transmitting intelligence without wires is the natural outcome of the most recent results of electrical investigations. Some enthusiasts have expressed their belief that telephony to any distance by induction through the air is possible. I cannot stretch my imagination so far, but I do firmly believe that it is practicable to disturb by means of powerful machines the electrostatic condition of the earth and thus transmit intelligible signals and perhaps power. In fact, what is there against the carrying out of such a scheme? We now know that electric vibration may be transmitted through a single conductor. Why then not try to avail ourselves of the earth for this purpose? We need not be frightened by the idea of distance. To the weary wanderer counting the mile-posts the earth may appear very large, but to that happiest of all men, the astronomer, who gazes at the heavens and by their standard judges the magnitude of our globe, it appears very small. And so I think it must seem to the electrician, for when he considers the speed with which an electric disturbance is propagated through the earth all his ideas of distance must completely vanish.

A point of great importance would be first to know what is the capacity of the earth? and what charge does it contain if electrified? Though we have no positive evidence of a charged body existing in space without other oppositely electrified bodies being near, there is a fair probability that the earth is such a body, for by whatever process it was separated from other bodies—and this is the accepted view of its origin—it must have retained a charge, as occurs in all processes of mechanical separation. If it be a charged body insulated in space its capacity should be extremely small—less than one-thousandth of a farad. But the upper strata of the air are conducting, and so, perhaps, is the medium in free space beyond the atmosphere, and these may contain an opposite charge. Then the capacity might be incomparably greater. In any case it is of the greatest importance to get an idea of what quantity of electricity the earth contains. It is difficult to say whether we shall ever acquire this necessary knowledge, but there is hope that we may, and that is, by means of electrical resonance. If ever we can ascertain at what period the earth's charge, when disturbed, oscillates with respect to an oppositely electrified system or known circuit, we shall know a fact possibly of the greatest importance to the welfare of the human race. I propose to seek for the period by means of an electrical oscillator, or a source of alternating electric currents. One of the terminals of the source would be connected to earth, as, for instance, to the city water-mains, the other to an insulated body of large surface. It is possible that the outer conducting air strata or free space contains an opposite charge and that, together with the earth, they form a condenser of very large capacity. In such case the period of vibration may be very low and an alternating dynamo machine might serve for the purpose of the experiment. I would then transform the current to a potential as high as it would be found possible and connect the ends of the high tension secondary to the ground and to the insulated body. By varying the frequency of the currents and carefully observing the potential of the insulated body and watching for the disturbance at various neighbouring points of the earth's surface resonance might be detected. Should, as the majority of scientific men in all probability believe, the period be extremely small, then a dynamo machine would not do and a proper electrical oscillator would have to be produced, and perhaps it might not be possible to obtain such rapid vibrations. But whether this be possible or not, and whether the earth contains a charge or not, and whatever may be its period of vibration, it certainly is possible—for of this we have daily evidence—to produce some electrical disturbance sufficiently powerful to be perceptible by suitable instruments at any point of the earth's surface.

Assume that a source of alternating currents, S, be connected, as in Fig 21, with one of its terminals to earth (conveniently to the water-mains) and with the other to a body of large surface, P. When the electric oscillation is set up there will be a movement of electricity in and out of P, and alternating currents will pass through the earth, converging to, or diverging from, the point, C, where the ground connection is made. In this manner neighbouring points on the earth's surface within a certain radius will be disturbed. But the disturbance will diminish with the distance, and the distance at which the effect will still be perceptible will depend on the quantity of electricity set in motion. Since the body, P, is insulated, in order to displace a considerable quantity the potential of the source must be excessive, since there would be limitations as to the surface of P. The conditions might be adjusted so that the generator or source, S, will set up the same electrical movement as though its circuit were closed. Thus it is certainly practicable to impress an electric vibration, at least of a certain low period upon the earth, by means of proper machinery. At what distance such a vibration might be made perceptible can only be conjectured. I have on another occasion considered the question how the earth might behave to electric disturbances. There is no doubt that since in such an experiment the electrical density at the surface could be but extremely small considering the size of the earth, the air would not act as a very disturbing factor, and there would be not much energy lost through the

* A lecture delivered before the Franklin Institute, at Philadelphia, February 24, 1893; and before the National Electric Light Association, at St. Louis, Mo., March 1, 1893.

action of the air, which would be the case if the density were great. Theoretically, then, it could not require a great amount of energy to produce a disturbance perceptible at a great distance, or even all over the surface of the globe. Now it is quite certain that at any point within a certain radius of the source, S, a properly-adjusted self-induction and capacity device can be set in action by resonance. But not only can this be done but another source, S_1 (Fig. 21) similar to S, or any number of such sources can be set to work in synchronism with the latter and the vibration thus intensified and spread over a large area, or a flow of electricity produced to or from the source S_1 if the same be of opposite phase to the source S. I think that beyond doubt it is possible to operate electrical devices in a city through the ground or pipe system by resonance from an electrical oscillator located at a central point. But the practical solution of this problem would be of incomparably smaller benefit to man than the realisation of the scheme of transmitting intelligence or perhaps power to any distance through the earth or environing medium. If this is at all possible, distance does not mean anything. Proper apparatus must first be produced by means of which the problem can be attacked, and I have devoted much thought to this subject. I am firmly convinced that it can be done, and hope that we shall live to see it done.

Fig. 21

Energy Transmission to Any Distance Without Wires.

On the Light Phenomena Produced by High-Frequency Currents of High Potential and General Remarks Relating to the Subject.

Returning now to the light effects which it has been the chief object to investigate, it is thought proper to divide these effects into four classes: (1) incandescence of a solid; (2) phosphorescence; (3) incandescence or phosphorescence of a rarefied gas; and (4) luminosity produced in a gas at ordinary pressure. The first question is, How are these luminous effects produced? In order to answer this question as satisfactorily as I am able to do in the light of accepted views, and with the experience acquired, and to add some interest to this demonstration, I shall dwell here upon a feature which I consider of great importance, inasmuch as it promises besides to throw a better light upon the nature of most of the phenomena produced by high frequency electric currents. I have on other occasions pointed out the great importance of the presence of the rarefied gas, or atomic medium in general, around the conductor through which alternate currents of high frequency are passed, as regards the heating of the conductor by the currents. My experiments described some time ago have shown that the higher the frequency and potential difference of the currents, the more important becomes the rarefied gas in which the conductor is immersed as a factor of the heating. The potential difference however, is, as I then pointed out, a more important element than the frequency. When both of these are sufficiently high, the heating may be almost entirely due to the presence of the rarefied gas. The experiments to follow will show the importance of the gas, or generally of gas at ordinary or other pressure as regards the incandescence or other luminous effects produced by currents of this kind.

I take two ordinary 50-volt 16 c.p. lamps which are in every respect alike, with the exception that one has been opened at the top and the air has filled the bulb, while the other is at the ordinary degree of exhaustion of commercial lamps. When I attach the lamp which is exhausted to the terminal of the secondary of the coil, which I have already used as in experiments illustrated in Fig. 15a, for instance, and turn on the current, the filament, as you have before seen, comes to high incandescence. When I attach the second lamp, which is filled with air, instead of the former, the filament still glows, but much less brightly. This experiment illustrates only in part the truth of the statements before made. The importance of the filaments being immersed in rarefied gas is plainly noticeable, but not to such a degree as might be desirable. The reason is that the secondary of this coil is wound for low tension, having only 150 turns, and the potential difference at the terminals of the lamps is therefore small. Were I to take another coil with many more turns in the secondary, the effect would be increased, since it depends partially on the potential difference, as before remarked. But since the effect likewise depends on the frequency, it may be properly stated that it depends on the time rate of the variation of the potential difference. The greater this variation, the more important becomes the gas as an element of heating. I can produce a much greater rate of variation in another way, which besides has the advantage of doing away with the objections which might be made in the experiment just shown, even if both the lamps were connected in series or multiple arc to the coil—namely, that in consequence of the reactions existing between the primary and secondary coil the conclusions are rendered uncertain. This result I secure by charging from an ordinary transformer, which is fed from the alternating current supply station, a battery of condensers, and discharging the latter directly through a circuit of small self-induction, as before illustrated in Figs. 19a, 19b, 19c.

In Figs. 22a, 22b, and 22c, the heavy copper bars, B B_1, are connected to the opposite coatings of a battery of condensers, or generally in such way that the high-frequency or sudden discharges are made to traverse them. I connect first an ordinary 50-volt incandescent lamp to the bars by means of the clamps, c c. The discharges being passed through the lamp, the filament is rendered incandescent, though the current through it is very small, and would not be nearly sufficient to produce a visible effect under the conditions of ordinary use of the lamp. Instead of this I now attach to the bars another lamp exactly like the first, but with the seal broken off, the bulb being therefore filled with air at ordinary pressure. When the discharges are directed through the filament, as before, it does not become incandescent. But the result might still be attributed to one of the many possible reactions. I therefore connect both the lamps in multiple arc, as illustrated in Fig. 22a. Passing the discharges through both the lamps, again the filament in the exhausted lamp, l, glows very brightly, while that in the non-exhausted lamp, l_1, remains dark, as previously. But it should not be thought that the latter lamp is taking only a small fraction of the energy supplied to both the lamps; on the contrary, it may consume a considerable portion of the energy, and it may become even hotter than the one which burns brightly. In this experiment the potential difference at the terminals of the lamps varies in sign theoretically three to four million times a second. The ends of the filaments are correspondingly electrified, and the gas in the bulbs is violently agitated, and a large portion of the supplied energy is thus converted into heat. In the non-exhausted bulb there being a few million times more gas molecules than in the exhausted one, the bombardment, which is most violent at the ends of the filament, in the neck of the bulb, consumes a large portion of the energy without producing any visible effect. The reason is that there being many molecules, the bombardment is quantitatively considerable, but the individual impacts are not very violent, as the speeds of the molecules are comparatively small owing to the small free path. In the exhausted bulb, on the contrary, the speeds are very great and the individual impacts are violent, and therefore better adapted to produce a visible effect. Besides, the convection of heat is greater in the former bulb. In both the bulbs the current traversing the filaments is very small, incomparably smaller than that which they require in an ordinary low frequency circuit. The potential difference, however, at the ends of the filaments is very great, and might be possibly 20,000 volts or more if the filaments were straight and their ends far apart. In the ordinary lamp a spark generally occurs between the ends of the filament or between the platinum wires outside, before such a difference of potential can be reached.

Showing the Effect of the Presence of a Gaseous Medium.

It might be objected in the experiment before shown that the lamps, being in multiple arc, the exhausted lamp might take a much larger current and that the effect observed might not be exactly attributable to the action of the gas in the bulbs. Such objections will lose much weight if I connect the lamp in series, with the same result. When this is done and the discharges are directed through the filaments it is again noted that the filament in the non-exhausted bulb, l_1, remains dark, while that in the exhausted one, l, glows even more intensely than under its normal conditions of working, Fig. 22b. According to general ideas the current through the filaments should now be the same, were it not modified by the presence of the gas around the filaments.

At this juncture I may point out another interesting feature, which illustrates the effect of the rate of change of potential of the currents. I will leave the two lamps connected in series to the bars, B B_1, as in the previous experiment, Fig. 22b, but will presently reduce considerably the frequency of the currents, which was excessive in the experiment just before shown. This I may do by inserting a self-induction coil in the path of the discharges, or by augmenting the capacity of the condensers. When I now pass these low frequency discharges through the lamps, the exhausted lamp, l, again is as bright as before, but it is noted also that the non-exhausted lamp, l_1, glows, though not quite as intensely as the other. Reducing the current through the lamps, I may bring the filament in the latter lamp to redness, and though the filament in the exhausted lamp, l, is bright, Fig. 22c, the degree of its incandescence is much smaller than in Fig. 22b, when the currents were of a much higher frequency.

(To be continued.)

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'BUS LIGHTING.

Mr. Freund would perhaps have been wise if he had remained silent under our exceptionally mild criticism of his paper. His letter in another column compels us to further justify our previous remarks, and to show how utterly untrustworthy his estimates are. If, in the first instance, our readers will compare our remarks on page 3 of our issue of July 7 with his comments, they will see that his reply is very roundabout. Is it right to estimate for lamps at a lower figure than they can be obtained now without explaining why you put that lower figure? He tells us that the company he speaks for is ready to undertake work on this estimate now, and thereby on his own figures and knowledge either to incur a considerable loss or to use lamps not obtained from those who control the existing patents. Enough, however, as to the lamps. Our contention is that Mr. Freund's estimate is misleading, and this can be shown by examining figures open to all. We will now examine another item in his estimate, and ask Mr. Freund to justify it by appeal to the future or in any way he likes. We say it is misleading, and further, we contend that such statements do a vast amount of harm in the industry, and those who make them should be called to book. We are told that a five-candle lamp is used on an average six hours per night, and the cost of electric current for 200 of these lamps for one year is £50. We must assume that each 'bus runs 365 days in the year, though, if it is any pleasure to Mr. Freund, we would make it a score or two less. This, at six hours a day, gives 2,190 hours for each lamp. We may also assume that each lamp takes 18 watts—that is, each lamp uses about 39½ Board of Trade units in the year. But the quantity put into the batteries in order to supply this is at least 25 per cent. more; and you have to pay for what you put into the battery, not for what you usefully take out. Therefore we may take it that each lamp will cost the amount chargeable for 48 units. How do you obtain your electrical energy for charging? If, when a suitable central station exists, probably from the supply mains, at a cost of from 3d. per unit upwards. Take 3d. as the cost. Then the 48 units per lamp cost you 12s. a year, and the cost for 200 such lamps is £120. Mr. Freund says £50. How does he get his £50? We have shown how we make that item at least £120, and probably in the vast majority of cases it will be nearer £200. So far as we can see, Mr. Freund has, and can only have, one answer to this if he attempts to justify himself, and that is to point out that some central stations claim to generate their electrical energy at a much lower figure than 3d. One, indeed, claims to be able to generate a Board of Trade unit at a cost under 1d. But surely Mr. Freund does not expect his readers to understand that if they light their 'buses with his lamps and batteries they will get their energy at anything approaching these figures, even if they put up an installation of their own for 200 'buses? It is perfectly evident, however, that the estimate in the paper contemplates charging from supply mains,

as it includes a rent of £10 a year for a "charging" station. We will recapitulate our figures so as to obviate the chance of Mr. Freund not understanding them:

5-c.p. lamp require 18 watts.

Each lamp runs 2,190 hours.

And thus uses per year 2,190 × 18 watts, or about 39½ Board of Trade units.

39½ units + losses require charging energy = 48 units.

48 units at 3d. per unit cost 12s.

∴ 200 lamps cost at 12s. per lamp = £120.

Mr. Freund may have been most conscientious in getting his figures from actual results, but they are not conclusive, and the profession generally would like to know a little more about the methods by which the figures in his estimate have been obtained.

We have now commented upon two of Mr. Freund's items. The lamps, it is explained, will be obtainable at the price named some time hence. In this connection, however, there is something more to say. The lamp-hours as given in the paper amount to 2,190. Taking only four replacements in the year, that gives a lamp life as 518 hours, nearly. We do not wish to cavil at this, but should like to have proof that under the conditions of 'bus-lighting the life is so long. Admitting that the existing lamps have a life of over 500 hours, we can hardly expect that in the near future new manufacturers selling at a third or fourth the price will produce a lamp of equally long life. If Mr. Freund is ready, as he says he is, to charge batteries for £50 for the charging current to run 200 5-c.p. lamps for 2,190 hours, he must, we think, have discovered something in connection with electrical energy and accumulators not generally known, and which, if on these figures admitting an ordinary manufacturer's profit, should revolutionise all our ideas of electrical work. Put in another way, he offers to energise a 5-c.p. lamp for a week, six hours each day, for 1·17 pence—forty-two hours for 1·17 pence. We confess to an utter inability to understand the figures. If they have been conscientiously examined, how is it done? Mr. Preece has said the electric light is the poor man's light, or something to that effect, but here we have a presumably responsible business man offering to supply current to run a 5-c.p. lamp six hours a day for a week for 1·17 pence. Prodigious! Prodigious!!

OBITUARY.

THE LATE SAMUEL EDMUND PHILLIPS.

It is with deep regret we have to record the death of Mr. Samuel Edmund Phillips, which occurred somewhat suddenly at his residence at Shooter's Hill, Kent, on Saturday last. He had been in failing health for some years, and suffered greatly from an internal complaint which proved to be caused by an ulcer.

Mr. Phillips, when a boy, was brought into contact with telegraphy, his father being at that time engaged with Dr. Whitehouse in carrying out experimental work in connection with the first Atlantic cable. He subsequently accompanied his father in the first Malta and Alexandria cable expedition, and in 1863 he became a member of the staff which Colonel Patrick Stewart formed to go out with the Persian Gulf cable, remaining at Bushire as a junior clerk. At the end of three years' service he returned to England, and obtained an appointment on the electrical staff of Messrs. Latimer Clark, Forde, and Co., leaving these gentlemen to become electrician to Mr. W. T. Henley, in whose service he remained for 10 years. At Mr. Henley's works he was appointed manager of the cable department, and occasionally he accompanied cable expeditions as head of the electrical department. In 1875 he joined Mr. W. Claude Johnson in partnership, and a small works was established at Charlton. This formed the nucleus of the present extensive range of factories which are so well known to all connected with the electrical industry throughout the world.

As an inventor Mr Phillips has given us the oil insulator, which has not only been largely adopted for telegraph lines in India, Egypt, and other countries, but has proved of immense value for overhead lines for electric lighting and the transmission of power in all quarters of the globe.

Mr. Phillips took the keenest interest in scientific matters generally, and to his good judgment and sound common sense may be attributed in a great measure the success of his undertakings. His genial manner and generous nature made him a universal favourite, and his loss will be deplored by a very wide circle of friends and acquaintances. It is not customary even in deploring the loss of an old and valued friend to abstain from the impersonal, yet we cannot help saying that the late Mr. Phillips was one of those quiet, unobtrusive men to whom England owes so much. He, in common with his surviving partner, was imbued with the view that it is necessary for a firm's success to have a reputation for thoroughness, and together they built up a reputation for the firm's work that gives it a foremost place among our manufacturers.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ACCUMULATOR TRACTION.

SIR,—If this little controversy has done nothing else, it appears to have thoroughly roused Mr. Sellon's interest in accumulator traction, judging from his powerful thirst for information. Birmingham furnishes the first, and at present the only, instance where our accumulators are being used on tramways, but what of that? A beginning must needs be made somewhere, and we have begun in Birmingham, making a right satisfactory start, too, while we were about it, for Mr. Carruthers Wain, the managing director of the line, expressed himself about our cells at the recent meeting of the Tramways Institute that they leave nothing to be desired. With these two essential points, "efficiency" and "durability" of our accumulators, proved and vouched for (see our previous letters), the cost of application is readily arrived at. But, first of all, Mr. Sellon wonders why an accumulator-car service is more regular and reliable than that where either the overhead or the conduit system is used, and wants to know the reasons. To make this quite clear, we need only to consider and compare the possible causes of stoppages on the various systems.

Eliminating damage to the cars, motors, and gearings as possibilities common to all three varieties, we have to deal with the supply of current to the motors and the interruptions which may occur. On accumulator cars a substantial switch is between cells and motor, and no matter what be the movements of the car there is always a sound solid connection to the source of supply. Now, compare this with the jumpy nature of a trolley contact, which has to be fished back into its place so frequently that in America "your trolley's off" has become proverbial. This happens when current is obtainable, but stretches of cable and wire are between supply station and motor, and the wire is liable to and does snap, or in winter it is occasionally coated with ice or the rails are flooded, rendering contact very imperfect; again, the trolley pole may break (a case in point was recorded in the *Electrician* of June 14, 1893, page 279, when a man had to stand on the roof of the car and hold the trolley to the overhead wire). No one will say that such occurrences are conducive to regularity. In the conduit system the slot frequently becomes clogged

with sand and street refuse, when the passengers may vary the monotony of a ride by pushing the car beyond the obstruction. But, above all, with the trolley or conduit system a temporary breakdown of the machinery at the central station may cause a stoppage along the entire line, whereas on the accumulator system only the one car is affected in which the cells have come to an end of their charge, and this can be pushed on by the car following it. The daily returns at Birmingham fully corroborate our assertion, showing that the service on the Bristol-road line has been practically free from interruptions.

Now, as to the cost of motive power per car mile of cars fitted with our accumulators, this we give herewith, and are quite prepared to stand by our figures at any time:

Line: 3 miles, double track.
Cars: 12, each for 52 passengers.
Weight: 12 tons.
Service: 5 minutes.
Speed: 6 miles per hour, including stoppages.
Time: 15 hours per day = 90 car miles.

	Cost per week.				Pence per car mile.
Fuel, 70s. per day	£24	10	0	...	·778
Oil, waste, and sundries	4	0	0	...	·127
Brushes on motors, lubrication at 10s. per car week...	6	0	0	...	·190
Wages at charging station, at £2. 10s. per car week	30	0	0	...	·952
Depreciation on buildings, hydraulic and generating plant at charging station (£6,600)	12	0	0	...	·381
Maintenance of accumulators	47	5	0	...	1·500
	£123	15	0	...	3·928

Then it must be remembered that with accumulator traction the maintenance of the roads is much cheaper, there being no electrical equipment on the line, and the capital outlay for the complete installation considerably lower than that for the other two systems. In the matter of total efficiency, accumulators again hold a great advantage. According to measurements made by Dr. Louis Bell on several American electrical tramways, the efficiency of the entire overhead system—viz., the proportion of the brake horse-power on the car motor as compared with the indicated horse-power of the engines at the generating stations—averages about 30 per cent. in everyday practice, while with accumulators, notwithstanding the increased weight of the latter, we arrive at a corresponding efficiency of over 40 per cent. It stands to reason that this must be so, as the expenditure from the cells is in direct proportion to the brake horse-power developed by the motor, while with the other systems the generating stations must be capable of furnishing the maximum current at any given moment, the average current, however, falling far short of the maximum.

We know that Mr. Sellon has mentioned the balance sheet of the Birmingham Central Tramways Company before, and we told him all we had to say with regard to this in our last letter. No doubt a copy of this as soon as it is printed will be delivered to him quite as early as to us, and set his mind at rest about the actual expenditure on the Bristol-road section. What we are prepared to work this line for under existing circumstances, and with the present plant, we must ask leave to withhold until the Board of the Birmingham Central Tramways Company have arrived at a decision on our proposal, but at what cost it could be worked by us or anybody with an entirely free hand is easily deduced from the foregoing tabulation.—Yours, etc., L. BROEKMAN, Manager,

The Epstein Electric Accumulator Company, Limited.
July 25, 1893.

'BUS-LIGHTING.

SIR,—Owing to my absence from town I have only to-day seen the comment you made in your issue of the 7th inst. on the paper I wrote for the Tramways Institute of Great Britain and Ireland. Allow me to say that I fail to reconcile *your introductory* statement—viz., "that you have narrowly watched this experiment"—with the remark that rumours contradictory to my statements are abroad. Of such anonymous assailants I cannot take any notice.

With regard to the figures which you recommend to be taken with caution, I can only say that they were most conscientiously taken from the actual results with over 150 omnibuses which perform quite publicly from and to Victoria Station, Pimlico. Far from attemping to paint matters rosy, the estimate was made with a view of accepting any challenge that members of the meeting should think fit to make. Likewise the criticism you bestowed on the price which I put down for incandescent lamps is unjustified. The first supply of incandescent lamps is covered in the outfit of £3. 10s. per 'bus. At the time the first renewals may be expected on contracts not yet entered the Ediswan patents will have expired, and you are, no doubt, aware that contracts are being freely entered by the largest electrical furnishers to supply best lamps at 1s. 6d., and less, after that date.

However, the best proof for an estimate to be *bonâ fide* is the readiness to carry it out, and I am pleased to inform you that the Bristöl Electric Safety Lamp Works, of 63, Queen Victoria-street, E.C., are prepared to contract with omnibus proprietors and tramway companies on the basis of my estimate. This firm will also undertake, at the present moment, to maintain the incandescent lamps of any number of cars at 1s. 6d. a piece, or on the figures of my estimate.

Your statement that "Mr. Bristöl has not sold any lamps to omnibus proprietors" does not testify to the carefulness of the watch you have kept. Quite the opposite is the case. The Bristöl Electric Safety Lamp Works, who hold all of Mr. Bristöl's patents, have, as far back as August, 1892, had an order from the London General Omnibus Company for 140 lamps and batteries. Being determined to make omnibus lighting by electricity a success, they tested their system privately on a small scale before they started in the streets of London. They started to light these 140 omnibuses in November and have, as far as electrical matters are concerned, not had to make the slightest alteration. That the number of 'buses lighted has been increased to 180, 153 of which run now daily, does not seem to be an unfavourable sign. The only difficulties encountered were of an administrative character. The batteries were not only irregularly returned, but were upset, left in the 'buses for several days, or lost altogether. The charging of the batteries is done by contract, and so is the maintenance of batteries and lamps as far as electrical wear and tear goes. The results seem too good to be believed by you, and I am sure Mr. Bristöl must feel your criticism more as a compliment than anything else.

You will oblige me by favouring my reply with a similarly prominent place in your valuable paper as was allotted to the attack.—Yours, etc., EDWIN FREUND.

ELECTRIC LOCOMOTION.

The first electric locomotive of any considerable size in the United States, and the first practically operative high-speed electric locomotive in the world, adapted to the steam railroad, has recently been completed at the Lynn Works of the General Electric Company, America, and will shortly be exhibited at the World's Fair. Its completion marks a distinct advance in electrical development. It is a 30 ton locomotive, designed for a normal speed of 30 miles an hour, primarily intended for operation on elevated railways, and for passenger and light-freight traffic on less important steam roads. It is of compact construction, solidly and substantially built, and runs on four 44in. wheels. Its dimensions are 10ft. 6in. long, 11ft. 6in. high, 8ft. 4in. broad, having its drawbars 2ft. 6in. from top of rail—the Manhattan elevated railway standard height. The drawbar pull is calculated at 12,000lb.

The propelling power is furnished by two electric motors of especial design and construction, each axle being provided with one motor. The motors are gearless, and are supported on spiral springs resting on the side frames of the locomotive truck. This method of suspension leaves the

wheels free to adjust themselves to the irregularities of the road-bed, and consequently the wear to both tracks and motors is diminished. The motor fields consist of massive iron castings, to which the hollow field spools are bolted. The armatures are of the iron-clad type, having each separate winding embedded in a mica-lined slot cut into the curved surface of the laminated iron armature body. The axles of the locomotive pass through the hollow shafts on which the armatures are mounted. These shafts rest in bearings of the motor frame, and are connected to the axles by universal couplings, which allow of freedom of motion in all directions. The commutators are of massive construction, and there are four sets of brushes to each commutator. The motors are controlled by means of a series parallel controller set up in the interior of the cab. This device embodies all the latest improvements made in this type of apparatus by the General Electric Company. Under test it is found that the series-parallel controller allows of a more gradual and easier starting of the electric motor, and the speed can be more delicately and instantaneously controlled than in the case of the steam locomotive.

The truck, suspended from the journal-boxes, is constructed of heavy I beams, and forms the foundation for the locomotive cab, of sheet iron, of symmetrical design, and so curved off as to diminish the atmospheric resistance as far as possible. The interior is finished in hard wood. Two sliding doors are placed at each side of the cab, and the windows are so arranged as to permit of an unobstructed view in all directions. There is ample space in the cab for the motor-man's movements, and it affords him considerably better protection than that usually vouchsafed the steam-locomotive engineer.

Train with 30 ton Electric Locomotive

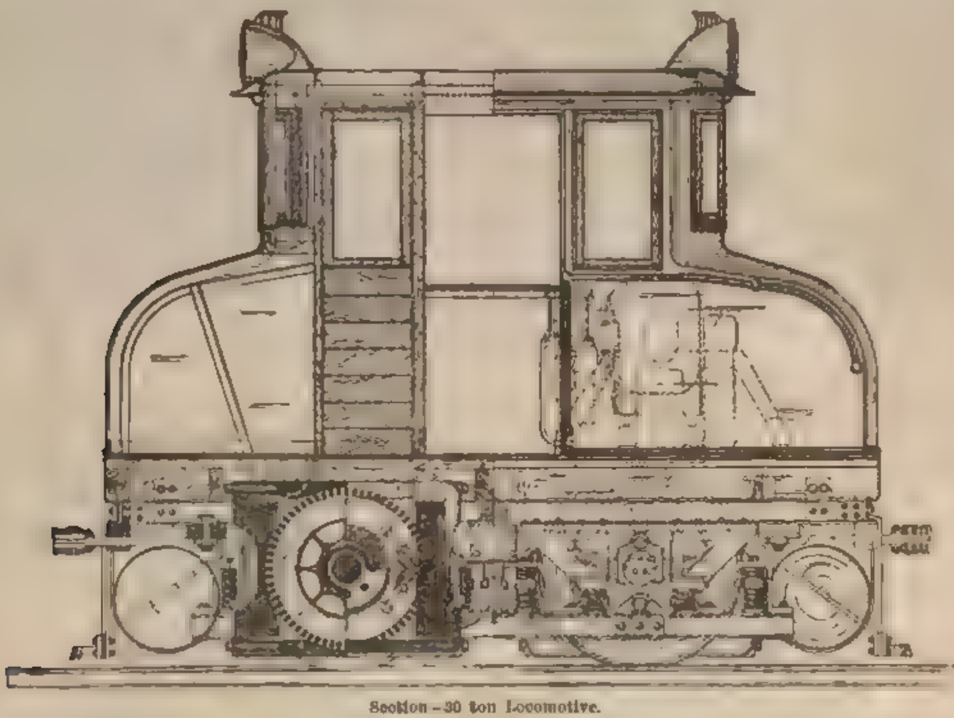
Truck—30 ton Locomotive.

The air for the brake is supplied by a special electrical air-compressor, which also operates the whistles. This air-pump has an oscillating cylinder of 6in. diameter, with a 6in. stroke, supplying 6,000 cubic inches of air per

minute at 70lb. pressure The motor is similar to the N.W.P. 2½ in general appearance, but is wound for a higher speed. The normal speed of the armature shaft is 675 revolutions, and of the crankshaft of the pump 110 revolutions. The dimensions of the air-compressor are: Length, 41in.; width, 16½in.; height, 25in. The pump motor is controlled by a special rheostat. This, by an intermediary device, is automatically regulated by the air pressure.

This locomotive has been designed for a normal speed exceeding 30 miles per hour. The use of these locomotives over very long distances is at present limited only by the cost of long lines of electric feeders, and until the problem offered by this condition is solved, restriction of its employment must necessarily exist. But for places comparatively near each other and where traffic is dense—the denser the better—the electric locomotive is peculiarly adapted, for here all the advantages of electric propulsion are available, unhampered by the extreme expense involved in long feeder lines.

The evolution of the use of the electric locomotive will probably follow along the lines dictated by expediency and favouring conditions. At first they will probably be used in elevated railroad service, and in New York, Brooklyn,



Section—30 ton Locomotive.

and Chicago alone, their advent will be hailed with a feeling of deep gratitude. They will then probably be adopted as feeders to the trunk lines, both for freight and passenger traffic, and to operate short suburban lines where a rapid efficient service is requisite. Their peculiar fitness for switching purposes will advance their use another step, and then slowly, as the different problems presented are overcome, they will invade the province of the trunk-line steam locomotive, and the millennium of railroad travel will be within the realities of life.

ON THE ELECTRIC LIGHT OF LIGHTHOUSES.*

EXPERIMENTS MADE BY THE LIGHTHOUSE DEPARTMENT OF FRANCE.

BY ANDRÉ BLONDEL.

Object of this Memoir.—The electric apparatus of lighthouses using the voltaic arc has undergone no modification for many years. The machine of De Meritens, adopted in 1881 at the lighthouse of Planier, is now in use in almost all French and foreign establishments, and gives excellent results; but of late years this machine has been severely criticised, because of its high price and antiquated type. From different quarters we have been urged to adopt more modern machines, and in particular continuous-current dynamos. With the object of improving, if possible, its installations, the Lighthouse Department of France has undertaken, on the initiative and under the direction of M. Bourdelles, inspector-general, since 1891, a series of systematic experiments which have had reference to the use of both continuous and alternate currents. The results have already been summarised in the notice on lighthouse apparatus presented by this department to the Chicago Exhibition. I propose here to explain in more detail the investigations that have been made with the two varieties of current at the lighthouse establishment, and at the same time the considerations that weigh in favour of each solution.

I shall point out first the general conditions that the machines and lamps should fulfil to ensure the safety and convenience of the service. Then I shall examine the manner in which continuous and alternate currents behave from the various points of view that have to be considered and the properties of the machines employed to produce them. Finally, I shall note the results of the comparisons made between the two systems.

This memoir will refer, then, only to the electric apparatus. The optical apparatus of electric lighthouses in France having been described in detail in the memoir above mentioned, we shall assume to be known.

General Observations on Machinery and Lamps.—The machines should be above all, of very strong construction. Their management should demand the least possible technical knowledge and the least possible attention. The speed of rotation should be moderate to reduce to the lowest point the causes of deterioration. We have decided in French lighthouses that it should not exceed 800 to 900 revolutions per minute, and for the machines of De Meritens, it has even been reduced to the half of this. Continuous lubrication must be provided. The motors may be steam, hot air, Dowson gas, petroleum, etc.*

I shall not undertake here the comparative study of these different apparatus. I shall only observe that the abandonment of the steam engine is only justified in exceptional cases, and that none of the motors suggested to replace it offer for lighthouses the same advantages of simplicity and safety. The use of the surface condenser or air condenser, which enables us to recover 75 per cent. of the water used, as also the experience obtained since 1891 in the lighthouse of Baleines, enables us to extend the application of steam even to lighthouses having a scanty supply of water.

Safety.—Besides the mechanical causes of deterioration, we have to take precautions against permanent or accidental causes arising from the current of the machine. With this object the intensity of the current must be reduced below that in ordinary use in industry, so that the rise of temperature of the windings may not exceed 20deg. C. in ordinary work, and 40deg. to 50deg.

* Paper read before the International Maritime Congress, London meeting, July, 1893.

* The hot air motor, although employed with success in certain French and other lighthouses, is only admissible in exceptional cases because of the numerous objections to which it is subject, such as irregularity of effort, lack of elasticity, etc.; and, above all, because of the excessive superintendence it requires from the attendant. The petroleum motor, which is still in use, is expensive in working, and not free from danger. Gas motors can only be used in towns having a gasworks. The solution proposed by Dr Hopkinson (Inst.C.E., December 7, 1886) has not yet been tried. The progress lately made in the employment of poor gases encourages us to believe that this method may one day be applied when the danger of intoxication by carbonic oxide has been overcome.

on short circuit. This result may be obtained without sensible diminution of the efficiency, while certainly prolonging the life of the dynamo. The deterioration of the commutators by sparks need only be feared in continuous current dynamos. The progress obtained in this direction relieves us now from any anxiety on this score. The accidental causes of deterioration to be guarded against all result from too sudden alterations in the current, consisting either in abrupt interruptions, or in short circuiting. In every case we ought to have at least a second generating unit in reserve ready for immediate use if the first has to be cut out of the circuit.

Gradation of Light, according to the Degree of Transparency of the Atmosphere.—In a certain number of old lighthouses two grades only are used, a simple and a double light—one, as the term implies, corresponding to double the intensity of current of the other. In French lighthouses of the old type these intensities are respectively 50 and 100 amperes. In the English lighthouse of St. Catherine they are 175 and 350 amperes. They are obtained by supplying the lamp either with one of De Meritens's machines, type G or L, or with two coupled in parallel circuit. But the gradation so obtained is imperfect, because the reduction of range due to atmospheric absorption varies in a much greater ratio than that of 2 to 1, when the weather changes from moderately clear to foggy. In average weather—that is to say, for about 20 per cent. of the year on the French coast of the Channel and the ocean—a current of 25 amperes is more than sufficient with bi-focal apparatus to enable the geographical range to be attained, and even surpassed. In the flashing apparatus, *feux éclairs*, an illumination is realised which reaches to 85 miles, whilst in foggy weather a double intensity corresponding to a current of 100 amperes only reaches 26 miles. In these conditions it is necessary that the intensity of the current should vary at least from 1 to 4, and that the weaker currents, which are the most used, should be obtained with suitable efficiency.

In French lighthouses the two extreme currents are 25 and 100 amperes. Many combinations may be made to obtain intermediate gradations.

1. Two machines, one supplying the minimum current, and the other, more powerful, supplying the maximum, each at their maximum efficiency. The only inconvenience of this method is that in case of breakdown of the large machine the small one does not constitute a sufficient reserve and that a third is necessary. Besides, the efficiency of the mechanical motor diminishes in general so quickly with the power that the advantage gained in electrical efficiency is rendered nugatory.

2. A single machine capable of furnishing, as desired, the various currents, and duplicated with a second similar unit as reserve. In this case the efficiency is necessarily much smaller with the smaller current.

3. A machine capable of supplying the mean current, combined with a secondary battery which, charged during the day, may be discharged at night alone during clear weather, and in parallel with the machine during foggy weather. This solution, suggested by different engineers,* seems to render possible a reduction of the staff, seeing that the maximum power is necessary during only two months of the year at most. But it is not so, and in any case the advantage so gained would be neutralised by the additional cost of the establishment and maintenance of a set of accumulators called on to act as much as 16 hours at a stretch, with a current of 15 amperes. The battery would be more cumbersome than a dynamo, and would require attention that can scarcely be expected from ordinary lighthouse attendants. Lastly, the efficiency would be more reduced owing to the absolute necessity in which we are placed of interpolating a considerable resistance, as we shall see latter, in a continuous-current arc circuit fed by a battery. Accumulators are not then applicable to the supply of an electric arc light for lighthouses with the arrangements in use at the present time. It by no means follows that they may not some day be utilised in a different manner.

4. Two machines, each having currents of 25 to 50 amperes, and arranged so as to be coupled in parallel in order to provide a current of 100 amperes.

This solution, which has been adopted for the service of French lighthouses, appears the simplest, the most favourable to symmetry in the installation, and the most economical from every point of view. It enables us to obtain a satisfactory efficiency with the 25 amperes current, and ensures a sufficient reserve in case of accident.

Arc Lamps.—These lamps, as we know, have their mechanism in the lower part, and rest directly on the platform, Fig. 9, of the optical apparatus. Its principal function is to constantly bring together the carbons as they are consumed. Some of them have a striking arrangement which automatically separates the carbons to start the arc. But none of them in ordinary working can increase the distance of the carbons if they have accidentally come too close to each other. In that respect an improvement might perhaps be introduced, but we can avoid the cause of too near an approach by suppressing, as we shall see later, the variations of the current.

The lamps for alternate currents, Fig. 9, almost the only ones at present used, all belong to the original Serrin type, or to that type modified in certain points of detail by MM. Berjot, Le Baron, Cholina, etc. The movement of approach, which is made under the action of the weight of the upper carbon holder, is governed by clockwork, with an escapement put in play by an electromagnet when the distance becomes too great.

The necessity of reducing the heating effect on the magnet and the change of attractive force that arises with the change of current has led for some time to the abandonment of the practice of putting the electromagnet in series with the principal current. In the new French lighthouses, we send, whatever the main current may be, the current of half of one of the machines of De Meritens through the electromagnet; the remainder goes directly to the lower carbon by another cable. This method, which requires three cables complicates the installation and the construction of the switchboard, although care may be taken to connect all the commutators of this board so as to enable the change of current to be made by one operation. It is more natural to employ, as in the lamps of Le Baron, an electromagnet placed in a shunt and wound with fine wire. The number of conductors is reduced to two, and there is no further need to split up the machine circuit.

The same type of regulator might also well be applied to continuous currents. Messrs. Sautter and Harlé have preferred to adopt for the experimental lamps of the lighthouse of La Hève a type analogous to that of the projectors, Fig. 2, in which the approach of the carbons is produced by a screw passing through the two carbon holders, and operated by an electromotor through a ratchet. The latter receives a shunt from the principal current through a relay controlled by a small electromagnet placed in shunt across the terminals of the lamp. Each movement of the screw is accompanied by a similar improvement of rotation of the socket of the lower carbon holder so as to regulate the shape of the carbons. But this movement is too slow to produce a favourable result. The principal advantage of this lamp consists in the employment of the solenoid, S, placed around the lower carbon, of which the purpose will be later explained. With the present lamp the regulation of the arc so that it may occupy the focus of the apparatus is effected, as is well known, by the aid of a screw that raises or lowers the two carbons simultaneously. The attendant constantly moves the screw so as to bring the image of the arc or of one of the carbons to a mark traced on the table. There would evidently be an advantage in producing this movement automatically, but the attempts made in this direction have not been sufficiently satisfactory to lead us to pursue them further. An automatic system would also have the disadvantage of not requiring the attention of the attendant, which it is as well to stimulate.

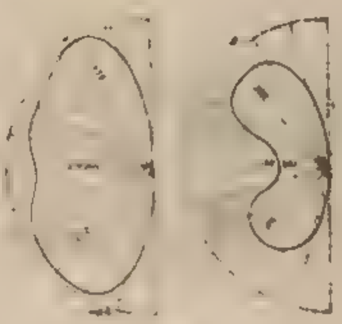


FIG. 8.

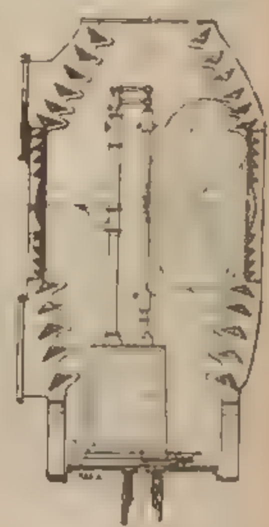


FIG. 9.

Influence of the Properties of the Dynamo on the Sensitiveness of Regulation of the Lamp.—The lamp consuming the whole of the current, the manner in which the pressure varies as a function of the current depends only on the construction of the machine, and the characteristic curve of supply at the lamp terminals only differs from the external characteristic of the dynamo by the small quantity representing the loss of pressure in the conductors. The method of regulation of the lamps (whether in series or in shunt) must therefore be chosen according to the form of the characteristic. If the latter has little slope (we shall see later that it is necessary for it to descend in the direction corresponding to a rising current) the amperes will vary more quickly, comparatively, than the volts for a given variation of distance between the carbons. The most sensitive mode of regulation will be then that in series; on the contrary, if the curve has a considerable slope regulation by a shunt should be preferred. Finally, if the characteristic is inclined at 45deg., which we shall see is practically the case with the dynamos of De Meritens, the two modes of regulation are equivalent, and, consequently, we ought to adopt the simplest—that is to say, regulation by a shunt.*

Reactions Produced on the Dynamo and the Motor by Variations in the Resistance of the Arc.—The electric arc being the only apparatus utilising the current, every variation of its resistance, and thus of the energy that it consumes, will be felt by the dynamo and the motor in the form of variation of speed, which, again, will modify the *régime* of the arc. These reciprocal reactions cause an oscillatory condition, resulting in periodical

* Inst.C.E., December 7, 1886.

* Differential regulation would give double the sensibility, but the complication it would involve in the distribution of the circuits renders it undesirable.

vibrations of the light that may end in its extinction or in a breakdown of the mechanism.

To avoid these difficulties, it is necessary to furnish the motors with a sufficiently sensitive governor, and to get rid of the oscillations by choosing the constants of the dynamos so that at about the usual current the demand it makes on the motor for power increases with the intensity,* or better, passes through a maximum,† an arrangement which is easily attainable for alternators.

EMPLOYMENT OF CONTINUOUS CURRENTS.

Section I. —Properties and Useful Effect of the Arc with Continuous Currents.

Constitution and Intrinsic Brightness.—It appears to be established that the arc consists of a current of carbon reduced to a state of vapour at the surface of the positive pole, which assumes

FIG. 2.

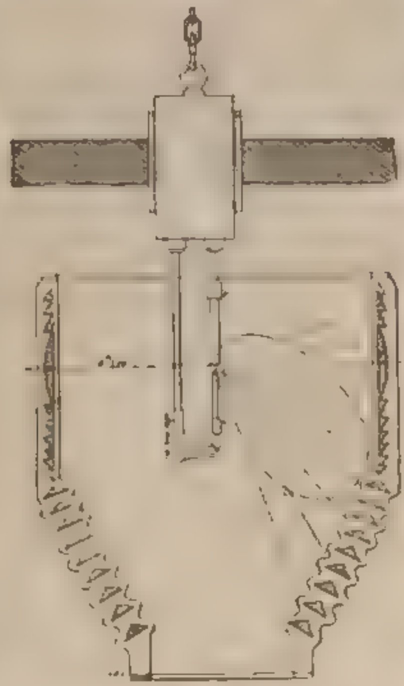
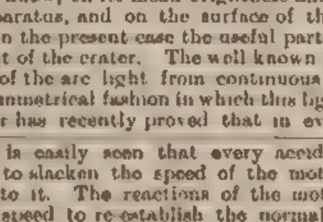


FIG. 3.

the form of a crater; owing to this circumstance, the positive pole constitutes the most brilliant part of the electric arc. It is estimated that it furnishes more than 85 per cent. of the light produced, while the negative carbon gives less than 10 per cent., and the arc properly so called less than 5 per cent. The temperature of volatilisation of carbon being a physical constant, the temperature of the crater must be invariable for a given carbon, and consequently also its intrinsic brightness—that is to say, per unit of surface. The experiments of Messrs. Abney, Rosetti, and Violle, etc., have shown that this is correct. But this law is only applicable to the maximum brightness; in fact, this maximum is only produced on a variable portion of the crater, and the mean brightness of the crater may vary within wide limits‡—that is to say, the total light that it emits divided by its total surface.



Distribution of the Light.—The power of a pencil of light produced by a luminous source placed in a given apparatus only depends, as we know, on its mean brightness and the geometrical form of the apparatus, and on the surface of the latter usefully illuminated. In the present case the useful parts are those which receive the light of the crater. The well known form of the curve of distribution of the arc light from continuous currents, Fig 8, shows the unsymmetrical fashion in which this light is distributed; and Mr. Trotter has recently proved that in every direction the quantity received is nearly proportional to the portion of the visible surface of the crater. It thus appears that above the horizontal plane through the edges of the crater the electric arc is of no great service.

Arrangement of the Carbons.—In placing in our present apparatus the positive carbon above the negative, as was done in the first applications, notably at the Lizard (England), the most important part of the apparatus was not made use of. Sir James Douglass proposed, in order to overcome this difficulty, to place one of the carbons eccentrically, so as to produce an oblique crater similar to that of projectors. But this arrangement, which only illuminates the apparatus over a very limited part, is unsuitable for lighthouses in the generality of cases.* It has then been attempted to place the positive carbon below and the negative above; but a further difficulty is then met with. The arc which with the crater above finds itself, so to speak, kept in place by the latter, now begins to travel round the edges, is uncertain, and is easily extinguished. This difficulty, not important with small lamps, becomes so serious with currents of more than 50 amperes, that it has hitherto completely hindered the employment of continuous currents. An attempt made in this direction at May Island (Scotland) in 1886 proved disappointing.

Messrs. Sautter, Harlé, and Co. have recently overcome the difficulty by a very ingenious application of electro-dynamic action; for this purpose they arranged concentrically to the lower carbon, Fig. 2, and as near as possible to the arc a solenoid formed of several turns of thick copper wire traversed by a shunt from the current of the lamp and protected by a refractory plate; the arc behaving like a fluid conducting body begins to turn around its own axis with a very rapid movement, as was shown by an instantaneous photographic record,† and immediately obtains, in virtue of its gyration, a great stability. The regularity in the shape of the carbons is favoured in some measure by the slow movement of rotation given as described above to the lower carbon. It is with a Sautter Harlé lamp of this system that the experiments have been made at the lighthouse establishment, and will be pursued at the lighthouse of La Heve. It might be well to adopt it for continuous currents, if we had to preserve the present forms of lamps and apparatus. In this case all the part of the optical apparatus below the focal plane not seeing the crater ought to have as its focus the point of the negative carbon. It would even be better to suppress it completely, and give to the cupola a larger development in diameter and in height, as was done for the apparatus of the Isle of May where the only mistake was in replacing by catadioptric rings the upper half of the dioptric drum.‡

Useful Effect obtained with Different Currents.—With arcs which are geometrically similar—that is to say, in which the proportion between the distance apart of the carbons, the diameter of the carbons, and the square root of the intensity remains the same—the occultations of the crater by the negative carbon have the same relative value. We must, then, always obtain the same optical effect at a great distance, and there would be no advantage in employing arcs of great intensity. In practice, this somewhat hasty conclusion is contradicted by experience, as is shown by the following table, in which are collected results obtained from experiments made with similar continuous current arcs.

Apparatus.	Diameter of carbons. Upper	Diameter of carbons. Lower	Intensity of current in amperes.	Pressure at the terminus in volts.	Power expended in watts.	Mean minimum power in carcels.	Luminous efficiency per watt in carcels.
	mms.	mms.					
Bi focal (type 1888) ...	10	13	25	50	1 250	411,000	329
,,	18	22	75	53	3,975	661 800	167
,,	18	25	90	52	4,680	900,000	192
Feu-éclair bi focal apparatus of La Heve ...	13	13	25	53	1 325	637,000	481
,,	18	21	47	55	2 585	916,000	354
,,	21	23	98	50	4 900	1,300,000	265
,,	18	23	94	57	5,358	1,781,000	332

This apparent contradiction might be explained by the small extent of the luminous surface compared to the inevitable aberra-

* In fact, it is easily seen that every accidental increase of intensity tends to slacken the speed of the motor, every diminution to accelerate it. The reactions of the motor tend, then, in any change of speed to re-establish the normal *regime*. On the contrary, if the power decrease, the variations of speed of the motor would reinforce the departures from the normal condition which gives rise to them.

† In this case the variations of power produced by a departure from the ordinary state are insensible.

‡ In the experiments made in 1878 at Chatham by R.E. officers, it was found that the mean brightness may vary from 26,000 to 76,000 candles per square inch. I have also observed similar variations.

* Except, of course, in cases where a projector might actually be used.

† *Lumiere Electrique*, vol. xlii., p. 60.

‡ Under these circumstances it might perhaps be advantageous in certain respects to turn round the half apparatus, giving it the arrangement shown by Fig 3. We might then replace the ordinary lamp by a lamp suspended to the upper part and analogous, save as regards power, to those employed in public lighting, in adopting for carrying the lower carbon a single rod placed on the land side, the lamp might be put in a case fixed to a small footbridge accessible to the attendant, and its replacing could be effected almost instantaneously, without any need of stopping the apparatus of rotation. Thanks to the employment of a positive carbon above, we should obtain a suitable condition of the arc more easily than now. Lastly, in giving to the apparatus a diameter of one millimetre in place of 0 60 millimetre, for example, we should amply compensate for the loss of useful surface due to the suppression of a part of the drum and of the ring, and should restore the horizontal divergence to a value nearly that which it has at present.

tions.* Further, we must not forget that when the maximum brightness is constant, the mean brightness of the useful incandescent part may be variable within certain limits, as was said above.

Influence of the Diameter of the Carbons.—Even admitting the constancy of the brightness, there is an advantage with regard to occultations in fixing the diameter as much as possible. We are limited only by the heating of the carbons, which increases their combustion and loss of energy, and may injure the sockets. The current given in the last line of the preceding table is for this reason inadmissible. If we calculate from the experiments of the table dimensions applicable to different currents, taking into account the laws of similarity, the following figures will be arrived at as maxima in the case of bare carbons:

Intensity of the current in amperes.	Upper carbon. Diameter in mms.	Upper carbon. Section in sq. mms.	Upper carbon. Intensity of current per sq. mm.	Lower carbon. Diameter in sq. mms.	Lower carbon. Section in sq. mms.	Lower carbon. Intensity of current in sq. mms.	Distance between carbons to be adopted in mms.
25	11 5	104	0·23	13	133	0·19	4 to 5
50	16	201	0·25	18	254	0·20	6
100	21	346	0·29	23	449	0·22	8

Separation of the Carbons.—The minimum distance apart which enables us to obtain from arcs of 25 amperes and upwards a light free from hissing is from 4mm. to 5mm., corresponding to a pressure of 45 volts at the arc and about 50 volts at the lamp terminals. There is an advantage with regard to optical efficiency in increasing the distance a little until the crater is completely free without passing the limit at which the arc becomes unstable and produces too much flame.

The preceding table indicates the data which seem to me the most favourable according to experiments and to the geometrical form of the arc.

Nature of the Carbons.—When the carbons are properly purified, as is generally the case for those in use in industry, which do not contain more than 2 to 3 per cent. of ash, the maximum intrinsic brightness remains practically constant, whatever is the nature of the carbons. That, at least, is the result I have obtained from a great number of comparisons made with the pyrophotometer.† But there is an advantage with regard to the occultations in reducing the diameter by employing the hardest possible carbons, which, owing to their great conductivity, can carry the most intense current without heating. The carbons of M. Carre, saturated with carbon by being many times successively soaked in syrup and baked, are successfully employed. They carry very well the current of 0·02 to 0·03 amperes per square millimetre given in the preceding table. To give to the arc a suitable stability we should add a core, but it should not be made too good a conductor, as otherwise the mean brightness might be diminished.‡

Conditions of Stability of the Arc.—The steadiness, independently of all conditions above treated relating to the mechanism of the lamps demands a special condition well known to electricians. It is necessary that the characteristic curve of supply at the terminals of the lamp, such as the curve M N, Fig. 4, for example, should be a falling curve, and have a sufficient slope.*

The engineers of the French navy have fixed the following slopes as necessary to the steadiness of a projector are regulated by hand†:

Arc of 45 amperes	43 volts.	
„ 65 „	45 „	Slope of 0·50 to 0·60
„ 75 „	48 „	„ 0·45 „ 0·55
„ 95 „	50 „	„ 0·35 „ 0·45

With automatic lamps in lighthouses, lower values may be adopted. It seems to be enough to have an E.M.F. of about 70 volts for one machine of constant potential, which corresponds to the following slopes:

Arc of 25 amperes.	V. at terminals = 50	V. at arc = 45	Slope = 1
„ 50 „	„ = 52	„ = 47	„ = 0·46
„ 100 „	„ = 55	„ = 50	„ = 0·40

This slope may be obtained either by the actual form of the external characteristic, or by the aid of an interpolated resistance. The wires which connect the machine to the lamp contribute to this effect; in a lighthouse 60m. high, with a connection of 20m. for example, a cable of 37 square millimetres in section, capable of transmitting 100 amperes, represents a resistance of about of 0·08 ohm, and absorbs nearly eight volts (without counting the resistance of the joints) with this current of 100 amperes.

(*To be continued.*)

* In consequence, in fact, of defects of construction in the refracting surface, the rays which are called "focal"—that is to say those which after refraction form the useful part of the pencil—do not all pass strictly through the geometrical focus of the apparatus. Those only are utilised which meet the incandescent part of the crater, and the number of them must evidently increase with the dimensions of the latter, until it becomes so great as to enclose all the focal rays. This view is justified by the important difference noticed between the actual divergence of the apparatus and the theoretical divergence calculated. For example, the apparatus of La Hève has furnished the following results with alternate currents:

Diameter of carbons.	Intensity.	Distance apart.	Divergence. Calculated.	Divergence. Measured.
10mm.	25 amp.	5mm.	0° 52′	1° 2′
23 „	95 „	5 „	1° 45	2° 15′

† V. *Bulletin de la Société Internationale des Electriciens*, March, 1893.

‡ The part played by the core may be considerable in respect of the pressure and the brightness, the same carbons at the same distance apart requiring differences of potential of 40 to 50 volts, according as the central part is composed of material more or less friable, conducting, and plentiful. This difference arises from the artificial increase of conductivity produced by the continued transference of these matters in the arc. This conductivity permits a part of the current to pass from one pole to the other without volatilising a corresponding quantity of carbon. In consequence of this action, although the maximum of brightness of the crater remains constant, the surface raised to this degree of incandescence may be found seriously reduced. This may be easily ascertained by considering a projection of the crater. We may thus understand how it is that soft core carbons tend to give a mean brightness inferior to that of homogeneous carbons or those with a hard core, and have always given inferior results in efficiency in lighthouse apparatus.

* The explanation of this condition has not been agreed upon. I have given one founded on a consideration of the characteristic of the arc which seems to me the most natural (*Lumière Electrique*, vol. xlii., p. 62).

† "Memoir on the Installations of Electric Lighting on Board Ships of War," by M. Dollard, naval engineer, 1889.

COMPANIES' REPORTS.

CITY AND SOUTH LONDON RAILWAY COMPANY.

Directors: Charles Grey Mott, Esq. (chairman), Harrow Weald Lodge, Stanmore; Charles Seymour Grenfell, Esq., Elibank, Taplow; Sampson Hanbury, Esq., Wyvenhoe Park, near Colchester; S. Barclay Heward, Esq., 96, Ashley-gardens, Westminster; Edwin Tate, Esq., 21, Mincing-lane, London, E.C.

Report of the Directors for the half year ending June 30, 1893, to be submitted to the half yearly ordinary general meeting of the Company to be held at Winchester House, Old Broad-street, on Tuesday, August 1, 1893, at 12 noon.

The receipts from all sources for the past half year have amounted to £23,159 6s. 3d., and the cost of working has been £14,964 0s. 6d., leaving a profit of £8,195 5s. 9d. Inclusive of the balance brought forward from December 31 last, the net revenue account shows an aggregate total of £9,073 12s. 10d. After making provision for the debenture and debenture stock interest, amounting to £4,110. 13s. 10d., a balance remains available for dividend of £4,962 19s. Out of this sum your Directors recommend the full dividend of 5 per cent. per annum be paid on the preference shares, and that a dividend at the rate of ¾ per cent. per annum be paid upon the consolidated ordinary stock, leaving a balance of £898 to be carried forward to the next account. The number of passengers conveyed during the six month ended June 30, 1893, exclusive of season-ticket holders, was 3,146,656, showing an increase over the corresponding period of the previous year of 333,494. This increased traffic has been carried with immunity from any accident whatever, and the train service has been worked with unfailing regularity. Your Directors regret that the amount paid for local rates and taxes continues to show an increase. The following table shows the number of passengers, exclusive of season ticket holders, carried since the opening of the railway in each half year:

Half year ended	Number of passengers.	Receipts (including season tickets).
Dec. 31, 1890 11 days about	165,000	£1,568 3 9
June 30, 1891	2,412,342	19,403 6 9
Dec. 31, 1891	2,719,055	19,798 16 6
June 30, 1892	2,813,162	20,931 4 2
Dec. 31, 1892	3,217,602	22,002 17 5
June 30, 1893	3,146,656	22,458 6 9
Total since opening of line	14,503,818	£106,162 15 4

The engineer certifies that the locomotives, rolling stock, generating plant, permanent way, and station buildings have been efficiently maintained in good working condition. The new sidings at the Stockwell terminus are nearly completed, and will shortly be brought into use. The working of the traffic will be greatly facilitated by this much needed accommodation. To meet the requirements of the increasing traffic, some additional rolling stock is now in course of construction. The Bill for the extension to Islington and other purposes has passed the House of Commons and now awaits the committee of the House of Lords, where it is unopposed. This Bill includes also the extension of time for the purchase of lands and construction of works under the Act of 1890 (Clapham Extension). During the half year £3,800 of terminable 5 per cent. debenture mortgage bonds have been paid off and replaced by 4 per cent. perpetual debenture stock. In order to provide at once some additional accommodation for passengers at the entrance to the King William-street Station, the lease of the adjoining premises in Arthur-street East has been acquired on favourable terms, and the requisite alterations will shortly be commenced.

CHILI TELEPHONE COMPANY, LIMITED.

Directors: Colonel R. Raynsford Jackson, 31, Harrington gardens South Kensington S W (chairman; Thomas Greenwood, Esq, Forest Lodge, Keston, Kent (vice chairman); Hon F. Ernest Allsopp, Hadsor, Droitwich; Frank W Jones, Esq, Morravale, Hampton Wick, Middlesex

Report of the Directors to be presented to the shareholders at the ordinary general meeting to be held at Winchester House Old Broad street, E C, on Wednesday, August 2, at 12 30 p.m

The business of the Company during the past year has shown a satisfactory improvement in dollars, but has been less profitable in sterling than that of previous years. This result is due to the depreciation in the sterling value of the dollar, which has fallen from 19d. on March 31, 1892, to 15d. on the same day this year.

The income in dollars from subscribers and other sources for the year 1892 93 was	$448,661
For the previous year	378,830
Showing an increase of	$69,831
The maintenance operating, and general expenses in Chili were, in 1891 92	$271,180
„ 1892 93	263,988
A reduction of	$7,192
The increase of income having been	$69,831
And the diminution of expenses	7,192
The total result was more favourable than in 1891 92 by	$77 023

The outgoings in 1891 92 were 71 6 per cent upon the gross revenue, but in 1892 93 they fell to 58 8 per cent, a reduction of nearly 13 per cent This satisfactory rate of profit was in dollars only; the unfavourable rates of exchange reduced the available income in sterling very considerably. The net profit on working was—

In 1892 3, at 18d. the $	£13,850
In 1891 2, at 19½d. the $	8,746
Increase, notwithstanding the fall of 1½ in the average value of the dollar	£5,104
But the loss on the sterling value of the liquid assets on March 31, comparing the same two years, was 4d. per $, and amounted to	4,750
Therefore the net increase in sterling was only	£354

The increase in the outgoings in England—including the interest on debentures—was £1,027, so that the net available sum for the year is less by £673 than in the previous year The profits having been used for capital purposes cannot be divided, and consequently the balance has been carried to a reserve account. As the tariff rates are paid in the paper dollar—now so seriously depreciated—the Board has found it imperative to increase those rates This has been done in some centres, and will be done in others A reduction in the number of subscribers may therefore be expected but the income will doubtless be maintained throughout, and probably considerably augmented when the irritation generally created by changes of this kind may exhaust itself. It will be observed that the capital outlay for the past year is £16,701 being £2 000 less than the previous year. This sum has been expended on the completion of the construction of the new trunk lines, and the usual preparation for connecting additional subscribers with the exchanges; the latter is now the only kind of expenditure on capital account. The 4,000 shares offered to the proprietors were all taken by them, and have all been paid for in full In accordance with the articles of association, Messrs. Allsopp and Greenwood retire from the Board of Directors, and being eligible offer themselves for re-election. The auditor Mr. Thomas A. Welton, also retires, and offers himself for re-election.

CROMPTON AND CO., LIMITED.

Directors: Viscount Emlyn (chairman); Rookes Evelyn Bell Crompton, Esq., and John Francis Albright, Esq (managing directors); H. H. J. W. Drummond, Esq.; Bernard Gibson, Esq; Carleton F. Tufnell, Esq.

Fifth report of the Directors, to be presented at the annual general meeting of the shareholders at the City Terminus Hotel Cannon street, in the city of London, on Monday, July 31, 1893, at 3 p.m.

The Directors herewith present to the shareholders the fifth annual statement of accounts made up to the 31st March last. From this it will be seen that although the gross profits show an increase upon the figures of the preceding year, the net results have been adversely affected by unusual and unforeseen expenditure In January last the boilers at the Chelmsford works suddenly gave out, and had to be replaced by others, and the year's working has had to bear a large share of the cost of this renewal and of the temporary arrangements necessitated thereby. It is highly improbable that any similar abnormal expenditure will recur in future years, but the Directors feel confident the shareholders will agree with them that it is right it should be charged to the year's account, even at the cost of a reduced dividend The orders in hand continue good, and negotiations for several important contracts are approaching completion. The net profits for the year amount to £11,953. 7s. 4d., and after providing for debenture interest and payments set out in the revenue accounts, and, deducting the interim dividends paid, there remains, with the £98. 10s. 2d. brought forward from last year, a balance available for dividend of £3,019. 12s. 8d. The Directors propose, after setting aside £750 as a provision for doubtful debts and contingencies, to declare a preference dividend of 2s 6d per share, making with the interim dividend already paid 6 per cent. per annum on the preference shares, to provide which the sum of £800 will be taken from the reserve fund. In accordance with the articles of association Mr. H H J. W. Drummond retires from the board of directors by rotation, but offers himself for re election. The auditors, Messrs. J. H Duncan and Co., also offer themselves for re-election.

Statement of Liabilities and Assets at March 31.

Capital and Liabilities.	£ s. d.	£ s. d.
Authorised issue 60,000 shares at £5		300,000 0 0
Ordinary shares, 8,000 issued as fully paid	40,000 0 0	
Ditto, 1,928 shares, £1 called, £1 928; less arrears, £276	1,652 0 0	
		41,652 0 0
Preference shares, 28,000 at £5	140,000 0 0	
Less arrears	4,755 0 0	
		135,245 0 0
		176,897 0 0
Debentures issued		47,805 0 0
Loan from bankers		18 000 0 0
Sundry creditors		26,190 19 8
Doubtful debts and contingencies accounts		336 10 9
Reserve fund		2,558 10 0
Revenue account balance		3,019 12 8
		£275,107 13 1

Property and Assets.	£ s. d.
Freehold property and ground rents	21,254 3 4
Stock in trade	64,236 1 11
Plant, tools, furniture, fixtures, etc.	44,399 0 0
Installations	850 0 0
Trade debtors	55,149 14 10
Investments in shares of other companies	12,004 0 2
Chelmsford Electric Lighting and other subsidiary companies	29,681 8 10
Cash at bankers and in office	3,044 4 0
Preliminary expenses—suspense account	900 0 0
Patents account	13,589 0 0
Goodwill	30,000 0 0
	£275,107 13 1

Profit and Loss Account Year ending March 31, 1893.

	£ s. d.
Trading and office expenses, salaries, agencies, etc.	23,788 9 10
Repairs to buildings and plant	1,104 3 11
Depreciation of plant and machinery, patents, and fixtures	3,596 19 4
Balance carried to revenue account	11,953 7 4
	£40,443 0 5

	£ s. d.
Gross profit from trading account, pupils' premiums, profits and dividends on investments	40,443 0 5
	£40,443 0 5

Revenue Account.

		£ s. d.
Interest on debentures		2,183 14 8
Preliminary expenses (written off)		269 11 9
Directors', trustees', and auditors' fees		1,245 0 8
Interim preference dividend paid December, 1891	£4,126 13 3	
Interim ordinary dividend paid December, 1891	975 0 0	
Income tax	232 4 6	
Balance available for present distribution	3,019 12 8	
		8,353 10 5
		£12,051 17 6

	£ s. d.
Balance from last year	98 10 2
Net profit from profit and loss account	11,953 7 4
	£12,051 17 6

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY, LIMITED.

Directors: James Staats Forbes, Esq (chairman); Major Samuel Flood Page (deputy chairman), the Earl of Lichfield; Shelford Bidwell, Esq., F R S; Ernest Villiers, Esq.

Tenth annual report of the Directors to be presented to the shareholders at the annual meeting to be held at the Cannon-street Hotel, E.C, on Friday, July 28 at 1 p m.

The business of the Company has resulted in a credit balance of £86,642. 5s. 1d. Of this, £20,632. 19s. 5d was distributed on March 14 last as an interim payment on the A shares. The Directors recommend a further distribution of £22,976. 1s. 5d. on the A shares; and the whole of the cumulative preference on

the A shares having now been paid, of £3,534 12s. on the B shares, the whole to be distributed in accordance with the provisions of Clause 87 of the articles of association. This will absorb £47 143 12s. 10d., leaving £39,498 12s. 3d., which the Directors have carried to the reserve fund, in accordance with Clause 89 of the articles of association. This will make the present distribution:

	Per share.
On the ordinary A shares	4s. 1d.
On the fully paid A shares allotted to the Swan United Company	5s. 1d.
On the fully-paid A shares allotted to the Edison Company	6s. 8½d.
On the B shares (fully paid)	3s. 0d.

All free of income tax.

The Directors are developing the manufacturing branch of the business, and are making and supplying electrical instruments, fittings, and electrical appliances. They have reopened the factory at Newcastle, and have opened depots for the sale of lamps and fittings in the principal towns in the provinces. Major Flood Page and Mr. Bidwell, F.R.S., retire by rotation from the Board, and offer themselves for re-election. Messrs. Welton, Jones, and Co., the auditors, offer themselves for re-election.

PROFIT AND LOSS ACCOUNT, YEAR ENDED JUNE 30, 1893.

Dr.	£	s.	d.
Stock on hand, July 1, 1892	45,225	19	11
Wages, purchases, etc.	86,139	8	11
Salaries, Directors' remuneration, rent, office expenses, insurance, income tax, general and law charges	16,265	18	9
Depreciation on plant, etc.	5,997	14	6
Balance	86,642	5	1
	£240,271	7	2
Cr.	£	s.	d.
Sale of lamps, fittings, royalty on holders, etc.	183,641	2	5
Interest, etc.	1,788	11	6
Stock on June 30, 1893	54,841	13	3
	£240,271	7	2

BALANCE-SHEET, JUNE 30, 1893.

Dr.	£.	s.	d.
Share capital:			
5,000 A shares of £5 each, fully paid, allotted to the Edison Electric Light Company, Limited	25,000	0	0
12,139 A shares of £5, fully paid allotted to the Swan United Electric Light Company, Limited, ranking up to 5 per cent. for dividend on the amount credited as paid up, and afterwards equally, per share, with A shares partly paid	60,695	0	0
89,261 A shares, £5 each, £3 paid	267,783	0	0
23,546 B shares, £5 each, fully paid	117,820	0	0
	471 298	0	0
Sundry credit balances	21,091	16	5
Reserve fund	32,262	0	11
Profit and loss as per appropriation account, £86 642. 5s. 1d. Less interim dividend paid on March 14, 1893, £20,632. 19s. 5d.	66,009	0	8
	£592,261	3	0
Cr.	£	s.	d.
Cost of patents, goodwill, preliminary outlay, loss on working, etc., as per last balance sheet	236,099	0	11
Further expenditure thereon	6 145	2	3
	242,244	3	2
Amount of B shares of this Company, issued as *per contra*	117,820	0	0
	360,064	3	2
Manchester Edison Swan Company, Limited, £100,000 B shares at nominal cost	12,000	0	0
Freehold property	40 437	12	2
Plant and stock	84,926	2	8
Debtors	52,765	5	0
Investment in consols at cost	20 000	0	0
Cash at bankers and in hand	22,068	0	0
	£592,261	3	0

STATEMENT SHOWING THE PROPOSED APPROPRIATION OF PROFITS.

		£ s. d.
To payment of an interim dividend as follows:		
Balance of arrears of cumulative preferential dividend on the A shares	£8,261 4 10	
3½ per cent. for the half-year ended Dec. 31, 1892	12,371 14 7	
		20,632 19 5
3½ per cent. for the half-year ended June 30, 1892	12,371 14 7	
3 per cent. on the A and B shares for the year ended June 30, 1893	14,138 18 10	
		26,510 13 5
Reserve fund		39,498 12 3
		£86,642 5 1
		£ s. d.
By balance of profit for current year to June 30, 1893		86,642 5 1
		£86,642 5 1

BUSINESS NOTES.

Brindisi.—The electric lighting of this town is to be extended.

Dieppe.—It is proposed to establish an electric tramway between Dieppe and Arques.

Canada.—Transmission of power plants are being rapidly extended in Canada.

Waterloo and City Railway Bill.—In the House of Commons on Tuesday, the Lords' amendments to this Bill were considered.

Lighting in Bolton.—The Gas Committee of the Corporation have decided to commence the laying of electric mains in the various streets.

Electric Construction Corporation.—The registered address of this Company is now Queen street-chambers, Queen street, Cheapside, London, E.C.

Edinburgh Electric Supply Company.—According to the resolution of June 28, and its confirmation on July 18, this Company will be wound up voluntarily.

Chiswick.—The Chiswick Local Board have affixed their seal to the deed of transfer and lease to the Bourne and Grant Electricity Supply Company, Limited, as to the provision of electric lighting in Chiswick.

Interest on Stock.—The interest on the 4 per cent. mortgage debenture stock of the Eastern Extension, Australasia and China Telegraph Company for the half year ended 31st July inst. will be paid by warrant on 1st August next.

Leeds.—The following tenders have been accepted for the extension works at Leeds for the Yorkshire House to House Electricity Company: Builders' works, W. Nicholson and Son, Hunslet; engines, dynamos, etc., J. Fowler and Co.

City Hall Lighting.—Among the many contracts obtained by Messrs. Drake and Gorham, within the last few days may be mentioned the rewiring and fitting of the hall and offices of the Company of Leather Sellers, in St. Helen's place.

Contracts Open.—As will be seen by our advertisement columns (p. xvi.), the St. Pancras Vestry invite tenders for building a chimney shaft and making a subway, and for supply of batteries, cables, copper strip, iron pipes, boilers, engines, and dynamos.

Bournemouth.—The Town Council have received a letter from the Bournemouth, etc., Electric Supply Company, in reply to the complaint as to the mode in which their works were carried out, stating that in all cases every care was taken in carrying out their works.

Crompton and Co.—The balance sheet of this Company shows a gross profit of £40 443 0s. 5d., and a net profit of £11,953. 7s. 4d. Last year the gross profit was £36,675. 6s. 7d., and the net profit £16,068. 16s. 11d., as will be seen from the balance sheet given in our issue of July 29, 1892.

Boy Messengers.—The District Messenger Company of Paris, Limited, is being formed with a capital of £200,000, divided into 112,000 7 per cent. preference shares of £1 each, taking precedence as to revenue and capital, 80,000 ordinary shares of £1 each, and 400 founders' shares of £20 each.

City and South London Railway Company.—The receipts for the week ending July 23 were £761, against £788 for the same period last year, or a decrease of £27. The total receipts for the second half year of 1893 show an increase of £317 over those for the corresponding period of 1892.

Guildford.—At the last meeting of the Rural Sanitary Authority it was mentioned that the Holloway Electricity Supply Company, Limited, had written that they intended making application for a provisional order to include the lighting of the two extra municipal portions of Guildford.

Direct Spanish Telegraph Company.—The Board have decided, subject to audit, to recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 4 per cent. per annum, free of income tax, on the ordinary shares, both for the half year ended June 30 last.

Notice of Dividend.—We have received notice that the directors of the Westminster Electric Supply Corporation, Limited, have declared an interim dividend for the half year ending June 30 last at the rate of 3 per cent. per annum, payable on September 18 next to all shareholders whose names are on the register on July 26.

Charing Cross and Strand Corporation.—The Directors of the Charing Cross and Strand Electricity Supply Corporation, Limited, at a Board meeting held on Thursday, July 20, decided to declare an interim dividend at the rate of 5 per cent. per annum on the ordinary shares (30,000 of £5 each). This will be paid on August 15, 1893.

Lighting of the Western Coast.—A movement is about to be set on foot for furthering the proposal made at a meeting of the Cardiff Chamber of Commerce by Captain Pomeroy with respect to the improved lighting of the coasts from Pembrokeshire, on the one hand, and Devonshire on the other, up to the mouth of the Severn.

Wrexham.—At the monthly meeting of the Town Council it was resolved to negotiate terms for taking over the provisional order of the Wrexham and District Electric Supply Company, Limited, but not to include the adoption or taking over of a provisional contract for works of supply either with the Brush Electric or any other company.

Doulton Electric Conduits.—Messrs. Doulton and Co., of Lambeth, request us to announce that their patent conduit for underground electric mains, together with a selection of pottery

for electrical purposes, which has been exhibited at their Lambeth showrooms during this week, will remain on view to engineers, on presentation of card, until August 5.

Manchester.—On Wednesday, at a meeting of the General Purposes Committee of the Manchester City Council, the question of telephones and traction was discussed. It was decided that in view of the decision of the Joint Committee, the municipal corporations must consider what action to take in regard to any Bills promoted to further electric traction.

Swansea.—The Property and General Purposes Committee of the Swansea County Council, at a meeting last week, reported that letters, which were read, had been received from the solicitors of Messrs. Crompton and Co., Limited and Messrs. Hannford and Wills, respecting electric lighting in the borough of Swansea. The letters were referred for report to a sub committee.

City Authorities and the Telephone.—The City Commission of Sewers decided on Tuesday, in view of the concessions asked for by the City of London Electric Lighting Company to lay telephone wires in the electric light mains, to grant the request on condition that telephones with double wires be supplied to the citizens at a cost of not more than £8 per annum. The charge at present is £20.

Oriental Telephone Company.—The directors of this Company have resolved to recommend to the shareholders, subject to final audit of the accounts, a dividend for the year ending 31st December last at the rate of 2½ per cent. on the entire paid up capital of the Company. The dividend being payable only to holders of the ordinary shares is equivalent to £3 12s 2d per cent. on each share of 11s. paid—the same rate as paid for the previous year.

Derby.—The Derby Corporation are laying down cables in the principal thoroughfares for lighting them by electricity. The generating station is erected on the site of Lombe's silk mill. At the present moment it has been arranged to erect 46 pillars and arc lamps in the town, and already the mains have been laid a considerable distance from the works. Messrs. Bramwell and Harris are the engineers, and Mr Vernon, of Derby, the contractor.

Edinburgh Tramways.—At the last meeting of the Lord Provost's Committee of Edinburgh Town Council, a letter was submitted from the Caledonian Electric Supply Company, intimating their intention to apply to Parliament for powers to construct electric apparatus to run electric cars between Coltbridge and Corstorphine. The committee agreed to recommend the magistrates and Council to refuse to give their consent to any such scheme.

Johnson and Phillips.—Messrs. Johnson and Phillips, with deep regret, announce the death of Mr. Samuel E. Phillips, which took place on the 22nd inst. As is well known to most of their friends Mr. Phillips had been in failing health for some years, and had of late taken no active part in the business of the firm. Mr. W. Claude Johnson henceforth becomes sole proprietor of the works and business, which will be carried on upon exactly the same lines as heretofore.

Windsor.—At the monthly meeting last week of the Town Council, some letters were read from the Board of Trade with reference to the Windsor Electric Lighting Company, to the effect that the company had failed to satisfy the Board of Trade that they were in a position to carry out the provisions of the order granted in 1890. The Council decided to appoint a committee from the authority of gentlemen not interested in the gas or electric lighting companies to consider the matter.

Aberdeen.—The Town Council, by virtue of its provisional order, is now busily engaged in carrying out its provisions. The total cost, exclusive of land, but including buildings, was estimated by the engineer to be £21,400; but the actual cost, now that the tenders have been received, has been found to work out very considerably less than this figure. There is good hope that the work will be completed by the end of the year. It is proposed to charge 7d. per Board of Trade unit for current.

Ipswich.—At a meeting of the Town Council last week, Mr. Pratt said the sub-committee on electric lighting had had a meeting, and that Mr. Catchpole and he were deputed to look for a site for the depôt, and he asked Mr Goddard, as chairman of the Waterworks Committee if they might visit the waterworks, for if room could be found there it would be a saving to the ratepayers of some £2,000. Mr Goddard said there could be no objection to the sub committee going to the waterworks.

Glasgow Telephones.—The report by Councillor Starke on the municipalisation of telephones in Glasgow has been discussed at a meeting of the Finance Committee of Glasgow Town Council. It was decided to recommend the Town Council to adopt the proposal contained in the report, and apply to the Postmaster General for a licence to lay down a telephone system throughout the city. In the report the necessary capital is estimated at £50,000, and with 4,000 subscribers the rent per annum for each instrument is put down at £4.

Electric and Automatic Engineering Company, Limited.—This Company has been registered by A. Aylard, Portsea Villa, Manor Park, Essex, with a capital of £10,000 in £1 shares. Object: to acquire, develop, and turn to account certain patents connected with automatic boxes worked by electrical, mechanical, or other power. The first directors—to be not less than three nor more than seven—are to be elected by the signatories to the memorandum of association. Qualification, £100; remuneration, £75 per annum; chairman, £25 extra.

Reading Tramways.—The tramways in Reading are the property of the Imperial Tramways Company, which has tramways in Bristol, Dublin, and other places. The company has just obtained electrical powers for working tramways, and it is suggested that if the Caversham to Whitley line could be arranged electric power would no doubt have to be applied to work it. The question of a new depôt has engaged the attention of the directors, and a new and more advantageous site has been selected near the Barracks terminus, Grovelands road East.

Lighting at Sevenoaks.—At a meeting last week of the Local Board, the Lighting Committee reported that they had before them the letter from Mr W. Hemmant, of Bulimba, Sevenoaks, proposing to form a company for the purpose of lighting Sevenoaks by electricity, and enquiring whether the Board would support an application for a provisional order; and the committee recommended that subject to the provisional order, as suggested in Mr Hemmant's letter, being satisfactory in detail, the Board do not oppose the proposal, but give the proposed company the usual permission in such cases.

Agency for Scotland.—Mr. W. C. Martin has ceased his connection with Messrs. Paterson and Cooper as agent for Scotland. They have appointed Mr. E. George Tidd to take his place. Mr. Tidd has for many years been connected with the firm and has personally superintended many of the most important electric light installations carried out by them in England. Mr Tidd has a thoroughly practical knowledge of electrical engineering, and is well known to electrical engineers in London. He is an associate member of the Institution of Civil Engineers and an associate of the Institution of Electrical Engineers.

Worcester.—A meeting of the Worcester Watch Committee was held last week, Alderman Hill presiding. Mr. Purches, city surveyor, reported strongly in favour of the generating station for electric lighting being at Powick Mills, on the River Teme, and pointing out that the extra power not required for lighting could be used for pumping at the waterworks, and for treating sewage at the contemplated sewage works. Mr. Preece confirmed Mr. Purches's conclusions. On the recommendation of the sub committee, the tender of Mr. T. Rowbotham, of Coventry road, Birmingham, for the erection of the generating station at Powick for £14,797 was accepted.

Madras Tramways.—The *Bombay Gazette* is informed by the secretary of the Madras Tramway Company that it is not true, as stated in one of the Madras papers, that the concession has been voided and that the deposit of 10,000 rupees paid into the municipal treasury has been forfeited. Nothing of the kind has happened. The final orders of the Local Government have not yet been issued. A special meeting of the Municipal Commissioners will be held to ask the Government to reconsider the question of the extension of the period for beginning the work. A public meeting will also be held to express the opinion of the Madras citizens, who feel very strongly on the subject.

Lighting at Weybridge.—At a meeting of the Chertsey Local Board, Mr. Yool moved that a communication be addressed to the Weybridge Electric Light Supply Company, drawing their attention to the section of the order which limited the time for removing the electric line placed above ground, and stating that the Authority did not consent to any line remaining above ground in contravention of the order. It was very important that they should proceed with the matter, because the contract with the lighting inspectors had only 14 months to run, and if the company failed to conform with the terms of the order it would be necessary for the parish to make some other arrangement with regard to lighting. Of course some time would be required to do that, and they did not want the village to be in darkness. The resolution was adopted.

Electric Traction in Liverpool.—At the half-yearly meeting of the Liverpool United Tramways and Omnibus Company, held at the offices, Pudsey street, Liverpool, last week, Mr. David Radcliffe, who presided, pointed out that during the 10 years of his chairmanship the shareholders had received dividends equal to 5 per cent., and in addition a very large sum had been put to reserve. The present lease with the Corporation of Liverpool had 11½ years to run, and it was intended to make another attempt to apply electric power as a means of haulage of tramway cars. They should first seek an extension of their lease as the capital outlay consequent upon new cars and equipment would be very costly, and one that could not be fixed on a lease of only 11½ years duration. Extensions were also required for residents near the city boundaries and outside, and when these were made the directors thought they could work useless and unused lines for which they had paid £54,810 rental in the past and were continuing to do so. Something should be done by the Corporation. They had carried in the half year just closed about 7,000,000 passengers, and their cars and omnibuses had travelled nearly 3,000,000 miles.

St. Pancras.—In the report of the Finance Committee of the London County Council on Tuesday, it was proposed that the Council should lend the Vestry of St. Pancras £15,400 towards the cost of its electric lighting works on condition that the sum was repaid in 42 years. A principle held dear by the Council is that no loan should be granted for a period longer than the probable duration of the works whose cost it is intended to defray, and in the light of this principle a diversity of opinion revealed itself as to the fitness of the conditions on which it was proposed that this particular loan should be granted. Several speakers thought the electric lighting works could not be expected to exist for 42 years, and more than one expressed a fear that the transaction proposed to be entered into would consequently be attended with financial risk. This prompted Mr. Westacott to the indignant enquiry whether any better security could be desired than the rates of St. Pancras. The debate was principally notable for the speech of Mr. Fletcher Moulton, Q.C., which reached a high oratorical level. Mr. Moulton held that 21 years was a

sufficiently long period of repayment for electric lighting works, though he was anxious to make an exception in the case of St. Pancras by reason of its being the pioneer parish in this important sphere of municipal enterprise. When it came to the vote, hostile amendments found but scanty support, and the recommendation of the committee was approved.

Electric Construction Company, Limited.—This Company has been registered by Linklater and Co., 2, Bond court, Walbrook, E.C. The capital is £400 000, divided into 150,000 ordinary and 50,000 preference shares of £2 each. The objects are to acquire the undertaking, business, and assets of the Electric Construction Corporation, Limited, upon such terms as the Board think fit, to undertake all or any of the liabilities of the said corporation, to carry on the business of electrical and mechanical engineers electricians, etc. The signatories with one share each are: Daniel Cooper, Bart., 6, De Vere gardens, S.W.; David Plunket, Q.C., M.P., 12, Mandeville place, W.; E. Garcke, Queen street chambers, E.C.; Henry C. Mance, K.B., C.I.E., Manora, Bedford; T. Parker, M.I.C.E., Newbridge, Wolverhampton; Philip E. Beachcroft, 112, Portsdown road, Maida Vale, W.; James W. Barclay, 5, Clarendon place, Hyde Park gardens, W. There shall not be less than three nor more than 10 directors exclusive of the managing director). The first are Sir Daniel Cooper, Bart., G.C.M.G.; Sir Henry Mance, C.I.E.; Right Hon. David Plunket, Q.C., M.P.; James W. Barclay, Philip E. Beachcroft, J. Irving Courtenay, James Pender, and Emile Garcke. Qualification: ordinary or preferred shares of £400. Remuneration: £1,500 per annum, and an additional sum equal to 10 per cent. of the net profits of any year in excess of the amount required to pay 6 per cent. on the ordinary paid up capital.

Liverpool Overhead Railway.—The report of the Directors of this Company for the half year ended the 30th ult. states that the railway was formally opened by the Marquis of Salisbury on the 4th February, and for public traffic on the 6th March. Owing to the delay in completing the electric signalling, only a 10 minutes' service could be worked until the 22nd May, since which date a five minutes' service has been established. The main structure of the line has been completed, and the electrical equipment has been working satisfactorily, the traffic being conducted with great regularity. The total number of passengers carried was 1,370,742, of which number 235,487 were first class, 956,922 second class, and 178,333 travelled with the cheap workmen's return tickets which the Company have recently issued. A contract has been entered into with Messrs. Holme and King, of Liverpool, for the extension of the railway to Crosby road, Seaforth, from which considerable additional traffic is expected. The Directors have decided to ask the shareholders for authority to issue the remaining preference capital of £45,000, but they do not anticipate that more than one-half will be required to provide funds for completion of the northern extension and for working capital. The accounts for the period during which the railway has been at work show that the gross receipts have been £12,352, and the working expenses, £6,990, leaving a balance carried to net revenue account of £5,361. After providing £1,623 for interest on mortgage debentures from March 6, and £122 for interest on calls paid in advance, etc., the balance available for dividend amounts to £3,644, out of which the directors recommend a dividend of 5 per cent. per annum upon the preference shares, which will absorb £351, leaving a balance of £3,293 to carry forward.

Hobart Electric Tramway.—A definite stage has been reached in the construction of the Hobart electric tramway system. The machinery at the generating station is now completely erected, and has been tested. There are four boilers of Marshall's multitubular 60 h.p. type, designed to give steam at a working pressure of 100lb. to the square inch. For the purpose of having a liberal tepid supply on hand, a huge water tank has been erected and connected with a Worthington steam pump, which forces the water through two of Marshall's 100 h.p. water heaters into the capacious reservoirs of the boilers. The necessary heat is supplied by the exhaust steam. There are three dynamos and engines. The latter are Willans's patent central valve high speed compound engines connected direct with Siemens H.B. 36-21 compound wound dynamos. They run at a speed of 350 revolutions per minute, giving off 500 volts and 250 amperes. The system adopted is the overhead type, and small galvanised steel wires have been used. These are stretched tight, and unsightliness from slack is avoided. But they lose power as the extremities of the circuits are approached, and to make up for this loss heavy feed wires are carried direct along each route on the poles. This makes the current of somewhere about equal strength over the whole line. The electricity passes down from the central overhead wire by a rubbing contact arrangement, which projects prominently aloft from the roof of each car. An insulated wire conveys it through a hollow standard to the terminal of the motors, fixed to the car carriage. From these wires the incandescent lamps for illuminating the cars are also fed. The cars were built for Siemens Bros. by the Lancaster Waggon Company, and will seat 48 passengers, divided equally between the lower and upper decks. Attached to each car are two of Siemens's electric motors of 15 h.p. each, so that the motive power on a car is equal to that of 30 horses. The plant will be strong enough, with the addition of another dynamo, to light the Tasmanian International Exhibition, and there is no little probability of this being carried out. The company's Act of Parliament empowers them to light the streets if required, but of course nothing is at present contemplated in this direction. The work of laying down the system has been done under the superintendence of Mr. C. A. Parker, who was assisted by Messrs. J. Wilkinson and T. Henwood. Mr. Lee L. Murray represents Messrs. Siemens Bros. in the colonies.

Lighting of Birmingham.—The question of electric lighting came up for consideration on Tuesday at a meeting of the City Council. The Mayor (Mr. Lawley Parker) moved, in accordance with the recommendation of the committee, that the notice of the Birmingham Electric Supply Company to apply for a provisional order extending their area of supply should be referred to the General Purposes Committee with power to take such action in relation thereto as they may think desirable for protecting the interests of the consumers and the Corporation. He said the committee had devoted much time to the consideration of this subject. A year ago they recommended that the matter should be delayed for 12 months, in order that further information might be obtained as to the success of the electric light from a commercial point of view, both in Birmingham and elsewhere; but they were agreed that, such information being obtained, they would then be bound to come to a conclusion one way or another, whether they should apply for a provisional order themselves, or whether they should grant on fair and proper terms power to the present or to some other company to extend electric lighting in the city. The Birmingham Electric Supply Company were seeking to obtain power to supply the electric light in Edgbaston and the jewellery district, and in due course they would have the details of the proposed order to deal with. It appeared to the committee that there were two ground which might justify the Council seeking for powers themselves. The first ground was a reasonable anticipation that the profits to be derived would be large, and the second was that it was necessary in order to safeguard the interests of the consumers and the public generally. In case the Corporation should decide on seeking a provisional order to supply the electric light in any part of the city, and especially the Edgbaston district and the jewellery quarter, they would have to acquire the present company's undertaking in order to make it succeed. They would have to acquire it by agreement, and he thought it was not unlikely that the company might require a considerable premium in anticipation of the future which they believed to be before them. Then they had to consider this aspect of the case, that while electric lighting was a success in some directions, they did not know that they had reached a point at which they could say, so far as the supply was concerned, that one or another was the right system, and that it might not be superseded by a better system in the future; and if they acquired the present plant, and laid down mains and so on for a new district, they might find there was a considerable deterioration in consequence of the discovery of some new system. This was a risk that ought to be taken into account before they came to a conclusion. Then they had to remember that electric lighting was a very technical matter, that they would be largely in the hands of engineers, and that the cost of working expenses would not be less, but probably greater, under the Corporation than they would be under a company. The General Purposes Committee, therefore, saw no encouragement to embark upon the enterprise so far as profit was concerned. Then with regard to the second point—the safeguarding of the interests of the public and the consumers—the Corporation had power to apply to the Board of Trade to revise the prices charged every seven years, and the period of appeal was now only three years distant. Besides this, there was no monopoly of supply; and the best safeguard was competition. The Corporation might at any time grant a concession to another company or undertake to supply the light themselves. Large consumers could also lay down their own installations, so that altogether ample safeguards already existed. On the whole the committee came to the conclusion that it would be better, for the present at least, that they should not become suppliers of the electric light and power themselves; and, therefore, that they should not oppose the application of the company for a further provisional order, except upon clauses; and here from past experience he believed they would not find the company unreasonable in negotiation with the Corporation. Mr. Reynolds seconded the resolution, which was carried.

Lighting of Chester.—Another report, this time by Mr. Preece, has been placed in the hands of the Watch Committee of the Chester Town Council, and was referred to last week at a meeting of this body. Alderman Gilbert, in view of the valuable information contained in the report, moved that it be printed and circulated among the members of the Council. Mr. J. J. Cunnah seconded. The Town Clerk (Mr. Saml. Smith) read the minutes of the Watch Committee meeting held on the 11th July, at which a notice was submitted to the effect that application was intended to be made on or before the 21st December next by memorial to the Board of Trade for a provisional order to be confirmed in Parliament in the ensuing session, authorising the Holloway Electricity Supply Company, London, to supply electricity for any public or private purpose within the area of the city of Chester. Letters were also read from Mr. Preece, in one of which he described Dr. Hopkinson as "the best man in Europe"; also his report on the prospects of electric lighting in the borough. After referring at some length on the advantages of the electric light and urging the Corporation to take the matter up in a bold spirit, Mr. Preece said in no case where the electric light had been adopted had the Corporation found it necessary to fall back upon the rates, and in no case had the introduction of the electric light injuriously affected the gas interest; indeed, it had generally the reverse effect. In Chester, with coal cheap and with water for condensing, there was no reason why the charge should be more than 6d. per supply unit, and as the gas was 3s. 4d. per thousand cubic feet, they would be able to compete with gas successfully as

regarded price. As to the installation station, the site by the market would be certainly central, but a high chimney placed there would be a nuisance and an eyesore and on the whole he considered it unsuitable. The wharf site was good for cheap carriage and water, but unless the buildings at the back, including the jam factory, could be obtained, the land would be of little use. That at present available would cost a large sum of money. The Hop-pole Paddock made a very suitable site as regarded size. Also it was near the canal, so that the water might be obtained for condensing and coal delivered cheaply. But owing to its proximity to their beautiful cathedral, it would, in his mind, be a pity to place the electric light station there if a more convenient site could be found elsewhere. Failing an outside site somewhere near the canal and railways, where land ought to be cheap, this site would, however, be the best. Assuming, therefore, that they decided upon the Hop-pole Paddock he should recommend them to use a low-pressure system, and if a demand arose in the suburbs and outlying districts too far to be reached by the low-pressure system, it would be easy to put up a small high-pressure alternating current plant, with sub-stations. If, however, they wanted to provide for the whole borough, and selected the wharf or obtained a site still further out of the town, then they must necessarily use a high-pressure system. As to the demand, Chester had a population of 37,000, and there were probably at the present moment about 40,000 gas burners fixed. It was fair to assume that about one-third of these lamps would be ultimately replaced by the electric light. The ultimate demand, allowing for the growth of population, would probably be about 20,000 35-watt lamps—i.e., there would be about 10,000 lamps burning at one time, for experience showed that the maximum number alight at one time never exceeded 50 per cent. of those fixed. He thought the Corporation would be justified in providing at present plant for only 5,000 35-watt lamps fixed. The estimated expenditure would be: buildings, £3,000; machinery, £6,500; battery, £1,000; mains, £4,000; contingencies and working capital, £500—total, £15,000. The ultimate expenditure for a plant to serve 20,000 lamps would be: buildings, £6,000; machinery, £20,500; batteries, £2,000; mains and distribution, £20,000; contingencies, £1,500—total, £50,000. At Chester the probable revenue and expenditure with 5,000 35-watt lamps fixed would be (assuming the charge to be 6d. per supply unit)—Expenses: working expenses and maintenance at 3.5d. per unit, £1,470; interest and sinking fund, £815—total, £2,285. Revenue: 5,000 lamps at 16s. per annum, £2,500, leaving a net profit after interest and sinking fund of £215. In conclusion, Mr. Preece remarked that an expenditure of £15,000 would be ample to commence with, but the buildings and equipment should be so designed as to be elastic and capable of extension with the growth of the business. It was moved by Mr. Deeley (the minutes continued), and seconded by Mr. Churton, that Dr. Hopkinson be appointed chief engineer, and be instructed to prepare a scheme, to advise on tenders, and to superintend the installation. An amendment was moved by Alderman Gilbert and seconded by Mr. Connah, that Mr. Gisbert Kapp be appointed engineer. The amendment was lost, and the original motion carried.

PROVISIONAL PATENTS, 1893.

JULY 17.

13858. **A galvanic element.** Albrecht Heil, 53, Chancery-lane, London. (Complete specification.)

JULY 18.

13888. **Improvements in electric current and current generator governors.** Charles Wiese, P. O. Box 1,071, Ottawa, Canada. (Complete specification.)

13889. **An electrical self-winding block.** John Shell Bolton and Thomas John Murday, 5, Elswick-place, Newcastle-on-Tyne.

13900. **Improvements in electric heating.** Richard George Bennett, 9, Kelmscott-road, Wandsworth Common, London.

13911. **An improved method of and apparatus for heating welding, or working metals electrically.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

JULY 19.

13976. **Improvements in dynamo brushes.** The London Electric Wire Company, Limited, and Henry Capel, Anchor Works, Playhouse-yard, Golden-lane, London.

13995. **Improvements in apparatus for the manufacture electrolytically of tubes and other articles of circular section.** Francis Edward Elmore, 28, Southampton-buildings, Chancery-lane, London.

13996. **Improvements in vehicles and electric locomotives for single-line elevated railways.** Fritz Bernhard Behr, 28, Southampton-buildings, Chancery-lane, London.

14000. **Improvements in and relating to electricity meters.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, Chancery-lane, London.

14003. **Improvements in or connected with electric-circuit closing devices for series circuits.** Albert Augustus Goldston, 4, South-street, Finsbury, London.

14012. **Improvements in electric batteries.** Henry Bonner, 11, Furnival-street, Holborn, London.

JULY 20.

14030. **Improvements in apparatus for the suspension of electric light fittings.** Bertram Thomas, 1, Springbank, Langham-road, Bowdon, Cheshire.

14056. **Improvements in electrolytes for primary batteries.** William Heaton Longsdorf, 73, Cheapside, London.

14076. **Improvements in electric measuring instruments.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Arakelyan Harry Armen, United States.) (Complete specification.)

14087. **Improvements relating to incandescence lamps.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (The General Electric Company, United States.)

14089. **Improvements relating to the manufacture of Paris blue or Berlin blue and of Berlin green by electrolysis, and to apparatus chiefly designed for use in such manufacture.** Hugo Goebel, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

JULY 21.

14091. **Improvements relating to electric fuses.** Francis William Thomas Brain, 20, High Holborn, London.

14105. **Illumination in connection with electric gas lighters.** August Eckstein and Herbert John Coates, 45, Chapel-street, Salford, Manchester.

13130. **Improvements in the electrolysis of iodides, bromides, nitrates and other salts.** James Hargreaves and Thomas Bird, 191, Fleet-street, London.

14131. **Improvements in the electrolysis of chlorides, iodides, bromides, nitrates, and other salts, and in apparatus therefor.** James Hargreaves and Thomas Bird, 191, Fleet-street, London.

14155. **Improvements in and connected with break-feed appliances for electric arc lamps.** Frederick John Beaumont, 166, Fleet-street, London.

14157. **Improvements in or relating to electricity motors.** Harry William Charles Cox, 51, Cricketfield-road, Lower Clapton, London.

14158. **A new or improved electric lifeboat messenger and tender.** Alexander Browne, 9, Warwick-court, Gray's Inn, London. (John Archibald Cox and Arthur W. Read, India.)

JULY 22.

14202. **Improvements in multipolar dynamo-electric generators and motors.** Lazarus Pyke and Edward Stephen Harris, 53, Chancery-lane, London.

14210. **An improvement in tubular posts for telegraphic or other purposes.** Siemens Bros. and Co., Limited, and Carl Ernst Julius May, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

SPECIFICATIONS PUBLISHED

1883.

5978. **Carbons for electric lamps.** Swan. (Second edition.)

1891.

536. **Dynamo-electric generators.** Atkinson. (Second edition.)

1892.

12665. **Secondary batteries.** Garassino.

13207. **Incandescent electric lamps.** Stern.

13358. **Alternate current circuits.** Mordey.

13507. **Electric conduits.** Scott.

14819. **Electric arc lamps.** Watt.

15887. **Obtaining metals by electrolysis.** Frei.

17982. **Brushes for electric-current machines.** Boult. (Boudreaux.)

1893.

7702. **Electric signalling for railways.** Johnson. (Lattig and another.)

8502. **Electrical railways and tramways.** Wise. (Ditto.)

10501. **Heating liquids by electricity.** Prichard.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¼
City of London	—	11
— Pref.	—	12½
Electric Construction	—	—
Gatti's	—	5½
House-to-House	5	3½
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4½
London Electric Supply	5	1
Metropolitan Electric Supply	—	[illegible]
National Telephone	5	5¼
St. James', Pref.	—	8½
Swan United	3½	3¼
Westminster Electric	—	6¼

NOTES.

Aniline.—A process of manufacturing aniline by electrolysis has been devised.

Telephone Wires.—It has been decided to permit the telephone wires in Manchester to be placed underground.

New Engine.—A new petroleum engine has been brought out by Messrs. Stephenson, of Newcastle-on-Tyne.

Liverpool Electric Railway.—It is suggested that it would be advantageous for the company to introduce season tickets.

St. Pancras.—It is suggested that arc lighting should be introduced in Gray's-inn-road and in the neighbourhood of King's Cross.

Traction in Westphalia.—It is said that Messrs. Siemens and Halske are to lay down a series of electric tramways in Rhenish Westphalia.

Lemberg.—Two lines of tramway are to be constructed and electrically equipped by Messrs. Siemens and Halske, and are to be ready for an exhibition next May.

Junior Engineering Society.—The summer excursion this year to Wilts., Devon, and Cornwall, is to commence on Friday, the 11th inst. Copy of programme may be obtained of the secretary.

Remscheid.—The electric tramway started last month has become so popular that the cars and plant are unable to deal with the traffic; hence the number of cars is to be increased from 11 to 20, and additions made to the generating plant.

Perseverance.—The result of perseverance is shown by the public statement made the other evening by a well-known electrical engineer that 15 years ago he was trying to eke out a living by teaching elementary science, whereas now he is an inventor and a prosperous man.

Accumulator Plates.—In a new composition M. Worms takes 945 parts of lead, 22 of antimony, and 13 of mercury. The lead is first melted, then the antimony is added, and finally the mercury is poured in only at the moment of running the composition in the mould.

Siam.—To keep up with one of the leading questions of the moment, a news agency telegraphed from Washington on Wednesday that an electric tramway, three miles long, has been put in operation at Bangkok by American capitalists. We believe the tramway was started some months ago.

The Institution.—Among the papers to be read during the next session will be one on "The Electrical Transmission and Distribution of Power at Niagara Falls," by Prof. George Forbes, F.R.S., member. A paper upon "The Electric Lighting of the City of London" has also been promised by Sir David Salomons, Bart., vice-president.

Owen's College, Manchester.—We are informed that the prize for the best essay on the technical applications of electricity has been awarded to Mr. J. R. Ashworth. This prize, of the value of £10, was given in the present year by Dr. Edward Hopkinson, the subject of the essay being "The Testing of the Efficiency of Dynamos and Motors."

Railway Station Lighting.—The Northern Railway Company of France—in accordance with its practice as already carried out on many of the stations along its lines—intends shortly to arrange for the electric lighting of the station at Montreuil-sur-Mer by means of accumulators, the necessary power being supplied by an engine used at the present time for pumping water.

Lighting of Balloons.—The "Phœnix," a German balloon, with which scientific investigations are being conducted at night, is lighted by four incandescent lamps, energised from a small battery arranged on the car. A captive "aerial castle," proposed to be used at the projected exhibition in Antwerp next year, is to be illuminated at night by many thousands of electric lights.

Traction in Leeds.—The majority of the Corporation, as the mayor recently mentioned, is in favour of electric traction, and probably, when the town acquires the tramways, electric traction on one system or another will be adopted. In this connection it may be well to record the fact that arbitration proceedings in the direction of purchasing the lines have taken place, and the decision of Sir Douglas Galton on the matter is expected in a month.

Chicago Electrical Congress.—The Royal Commission for the Chicago Exhibition has appointed Major-General C. E. Webber as one of the delegates to the electrical congress to be held at the exhibition. We understand that General Webber's name has been forwarded to the Secretary of State for Foreign Affairs for transmission to Chicago through the American Ambassador, and that Sir Henry Woods, secretary to the Royal Commission, who is now at Chicago, has been informed of the appointment.

Lighting in Manchester.—The generating station of the Corporation is now being set to work. It is situated in Dickinson-street, and on Monday the Free Trade Hall was lighted for the first time. On Tuesday arrangements were completed for the turning on of the light at the Bank of England, and other buildings within the area of supply will be connected to the mains as expeditiously as possible. It is expected that so far as the orders already received are concerned, the work will be completed by the end of this month.

South London Railway.—It is noteworthy that the percentage of working expenses to gross receipts is gradually diminishing. The first half-year the line was worked the expenses were 79 per cent. of the receipts, the second half-year 76 per cent, the third half-year 70 per cent., the fourth 67·0 per cent., and the fifth and last 64·6 per cent. These figures included the lifts, and if these were deducted the expenses would only be about 56½ per cent., which is very nearly the same as on ordinary railways.

Koenigsberg.—Those interested in central-station work will find a full illustrated description of the municipal lighting of Koenigsberg, Prussia, by F. Uppenborn, in the *Electrotechnische Zeitschrift* for July 21. The installation was carried out by Naglo Bros., of Berlin. Vertical engines driving the dynamos direct are used. Diagrams of connections are given. Not the least interesting parts of this installation are the switchboard, worked by handle and gear, and the ventilation of the junction-boxes in the streets by air-shafts.

Traction in Vienna.—A commission of the Municipal Council has, in consequence of the proposals of the Vienna Tramway Company for improving the facilities for transit, been considering the subject. The commission regard the introduction of electricity as the motive power on tramways as a suitable method for removing the many difficulties encountered in the working of the lines, for facilitating the continuation of separate lines through the inner town, and for increasing the speed and carrying capacity of the tramways. A change in this direction was, however, not to be entirely carried out as proposed by the tramway company, but the system must be extended in all parts of the city

where there was plenty of traffic. The recommendations of the commission have been adopted by the Municipal Council.

City and Guilds of London Institute.—The council, on the 31st ult., awarded the diploma of associate of the City and Guilds Institute to the following third-year students of the Institution: Civil and mechanical engineering—K. W. Digby, G. A. Fry, G. H. Heelas, R. F. Krall, H. F. Robinson, A. E. H. Sonneborn, C. V. Drysdale, T. L. D. Hadwen, E. L. Joselin, H. C. Leake, R. D. T. Roe, and W. T. W. Sussman. Physics and electrical engineering—G. H. Ballie, W. A. Brodie, W. Casson, J. R. Dick, A. H. Finlay, E. E. Gunter, W. E. Miller, J. Barnard, R. B. Burrowes, W. R. Cooper, W. H. Everett, E. G. Fleming, T. Hemmant, N. Ward, and C. H. C. Woodhouse. Applied chemistry—O. F. Russell.

Accumulator Cars in Milan.—As mentioned in our last issue, the starting of the storage battery cars in Milan took place on the 20th ult. in the presence of members of the local authorities and others. The cars, which have been made by the Oerlikon Engineering Works, are of the same type as those shown by the latter at the Frankfort Electrical Exhibition. Each car accommodates 34 passengers, 18 being seated, and the remainder being carried on the two platforms. The battery is composed of 64 cells arranged under the seats, and has a capacity of 200 ampere-hours. The motors are of 10 h.p., and the maximum speed obtainable is said to be 20 miles an hour, but a rate of only 11 miles is permitted. The journey from Milan to Monza is accomplished ordinarily in 55 minutes, but with the electric cars it is done in 35 minutes.

Electricity a Disinfectant.—The "medical electrician" claims that the germ of life is electricity! but apparently it is capable also of destroying life to an equal extent. This is a contradiction in terms and probably also in facts; but let that pass. Mr. Albert E. Woolf has devised a method of disinfecting sewage by the electrolysis of sea water. At Brewsters, a small town situated about 20 miles from New York, it was found that sewage was percolating through a marsh into one of the streams from which New York derives its water supply; and to remedy this, a steam plant of 15 h.p. has been put down for the purification of the Brewsters sewage. The dynamo furnishes 700 amperes at a pressure of 5 volts, a current amply large enough to electrolyse and thoroughly disinfect the liquid sewage from which danger arose.

An Early Electric Railroader.—The United States patent office electrical department must have a pretty lively time of it what with glow lamp and trolley wire claims to priority of invention. The latter subject has an especial interest just now from the enormous developments which promise to take place during the next few years; and no surprise would be felt at efforts being made by all the traction interests to obtain the earliest patents on fundamental points. Mr. T. C. Martin, the well known joint editor of our New York namesake, has however unearthed a certain Dr. Cotton, who was born as long ago as 1814, and in 1847 constructed an electric locomotive which ran upon insulated rails, one being used for the lead and the other for the return. Dr. Cotton is still alive and vigorous, maintaining a prosperous dental business in New York City.

The Three-Phase Systems.—An installation of electrical transmission of power on the three-phase system has recently been set in operation at Wangen in Wurtemburg. There are two power stations about one mile apart. The chief depôt contains a dynamo of 200 h.p. running at 265 revolutions, and driven indirectly by a Girard turbine. After passing through the measuring instruments, the current is transformed up to 5,200 volts. At the second generating station the power is obtained from the reserve of a timber yard, and this is used to operate a 100-h.p. dynamo. The current from this is also transformed up to 5,200 volts, and both machines supply into one set of mains, which are carried overhead a distance of 5½ miles to Wangen. Here the current is led to three transformer stations, where it is converted down to 110 volts. At this pressure the current is used for street lighting, and for operating motors in various establishments.

Schuckert's Electrical Plant.—Messrs. Schuckert and Co., of Nuremberg, have issued a pamphlet giving a short account of the development of their works, which were first established in 1873. It is published in connection with the company's exhibits at the Chicago Exhibition, and a copy of it has reached us from Mr. C. A. Muller, of Bradford, who is the general agent in this country. The pamphlet, which traces a history of the progress of the firm, contains some excellent views of the works and shops, and illustrations and descriptions of the company's dynamos, arc lamps, measuring instruments, searchlights, etc. A description, with plans and sections, is given of the Hanover central station, which was carried out by the firm. The extent of the works is shown by the fact that 1,500 persons are employed, and the annual output amounts to more than 1,000 dynamos and 6,000 arc lamps, apart from other apparatus.

Electric Elevators.—Some efforts—though not very extensive as yet—have been made by the Otis Elevator Company of London to develop the employment of electricity for operating the elevators that become an essential part of the large buildings now so common in our large cities; but there is, one would think, ample scope for a rapid increase in these appliances, seeing that a supply of current may be obtained so easily in the centres of population. A diagram, accompanied by figures as to cost of operation, etc., is given by the *Canadian Engineer* in a recent issue, showing the current required by an electric elevator in a Toronto building, where the cage takes 16 seconds to ascend. To do this the motor requires 70 amperes at a pressure of 230 volts; and current being charged by meter at the rate of four cents—or, say, 2d. per horse-power—the cost per round trip is not more than one fifth of a cent—or, say, one-tenth of a penny.

Technical Training.—Under the head of "The Student Course at Lynn," Mr. John E. Pitman has given in the "Year-book of the Society of Engineers," Minnesota University, details of how to apply for admission as a student at the expert department of the General Electric Company of America. Over 700 applications, it appears, are now on file (which beats Prof. Kennedy's 380); an average of four a day come in, and 85 per cent. are college graduates. The course may include six weeks in the shop plant, 11 weeks in the arc department, and 10 in the continuous incandescent; nine weeks with motors and generators, 11 weeks with the alternating system; three weeks in motor testing, and two in the blacksmith's shop. In addition, experimental work is done, such as testing special machines. In return, students are paid for the first three months 2½d. an hour, then 3½d., and 5d., and for the last three months 6d. an hour. If they stop after the year, 7½d. an hour is paid. The working day is nominally of 10 hours.

Fatal Accident in Rome.—An accident, resulting in the death of two trimmers, occurred last week in Rome. An arc lamp in the Piazza of the Quirinal became extinguished, and one of the men, placing a ladder against the

standard, mounted and neglected to switch off the current before taking hold of the carbons. The result was that he was instantly killed, and his companion not knowing that the current had not been turned off, endeavoured to rectify matters and met with the same fate. Questioned on the subject by a correspondent, Prof. Mengarini, a well known Italian electrical engineer, said that the pressure of the current which killed each of the two men, and which only left a very slight burn on the fingers, was of 2,000 volts, and that it was an alternating current of 5,000 alternations per minute. He had seen the bodies 10 minutes after death, perhaps even less, and the expression on the face of each was perfectly calm. It was his opinion that there was no necessity to keep the current on for so long a time at executions in America.

A New Lamp Filament.—We have been favoured with specimens of a new compound material for incandescent lamp filaments. It has been produced by Mr. A. Shippey after four years' experiments. The material can be pressed into sheets and cut into different shapes according to actual requirements, or it can be drawn into very fine wire. The material is termed "Fiberite." We are informed that when carbonised by a new process devised by Mr. Shippey, the filaments are rendered very strong, and capable of standing from 150 to 200 volts in case of need. Messrs. Shippey state that the new lamps are made both in vacuous and non-vacuous types, the bulbs in the latter case being filled under pressure with a highly-attenuated vapour, and as the bulbs can be filled in batches of 500 to 1,000 at a time, great economy is said to be obtained by this new process of manufacture. It is claimed that good lamps can be produced on this method, and be sold to large consumers at from 8d. to 8½d. per lamp, and that the annual cost to consumers will amount to 1s. per lamp.

The Chicago Electrical Section.—In a letter to the *Times* of Wednesday, Mr. Conrad W. Cooke, who had agreed with one of the Royal Commissioners to proceed to Chicago to act as judge in the electricity section, complains of several postponements of the work of the judges, and through which he had been obliged to send in his resignation. Apart from personal matters, he states that the conditions imposed upon the judges are impossible to fulfil. Continuing, he says:—"According to the instructions, each judge is required to examine every individual object exhibited by every exhibitor in his section, and to make a report in writing, over his signature, thereon, stating his reasons for giving or withholding an award to that particular object; and, moreover, he has, in addition, to prepare an abstract report upon each object he examines, and such abstracts are to be inscribed in the diploma to be presented to the exhibitor, while the full reports are to be published afterwards and will form part of the literature of the exhibition. The fulfilment of such a condition would involve many months of the closest possible work."

Increasing Tractive Power.—The tendency of electric street tramway practice in the United States—says Mr. W. E. Harrington, in the *Electrical World*, is towards the use of a single motor, operating as a rule on one axle; but owing to steep grades and large loads, necessitating heavy currents, it is found that there is often a difficulty in preventing slip, if not even occasional overloads of the motors. Accordingly, the above-named gentleman suggests the use of two magnetic pulleys—one on each axle—connected by means of a flexible iron band. The magnetising coils of these pulleys are switched in and out in series with the motor, so that the adherence varies directly with the current; both axles are thus driven by the motor, and therefore it is claimed that the tractive power is very materially increased at slight expenditure of electric energy. The appliance is ingenious enough, but one would doubt whether the gain more than counterbalanced actual loss of current, with the greater complication, as compared, say, with the use of differential gear thrown in and out by means of a magnetic clutch.

Lighting by Reflected Light.—The Société Alsasienne of Belfort uses to a considerable extent the method of reflecting the light of the arc lamp from the ceiling. The positive carbon is placed below so that the hollow crater throws its rays upwards to a reflecting screen. For rooms 11ft. in height the company recommend 10-ampere lamps, and for rooms of 15ft. a 15-ampere lamp. The price of a complete installation is estimated on the average as £16 per lamp of 10 amperes, and £20 per lamp of 15 amperes; and the motive power 0·8 h.p., and 1·2 h.p. respectively per lamp. The working expenses are given at £4. 16s. and £6. 8s. for these two kinds of lamps per year of 700 hours. This method loses part of the light, but where the walls and ceilings are whitewashed, it has the advantage of giving absolutely no shadows and of furnishing a light more nearly that of daylight than any other artificial light. In spinning and weaving mills it is found to take 25 per cent more power than with incandescent lamps, but the superior advantages more than compensate for the loss. It is also recommended for school lighting as being less injurious to the eyes of children than other lights.

Central Stations in France.—We have no great reason to feel proud of the "rapidity" shown by this country in developing the supply of electric energy for lighting purposes, although the past two or three years show an improvement in this respect. Statistics of what has been so far accomplished by our neighbours across the Channel, as published in *L'Industrie Electrique*—give a total of 255 central stations for the distribution of electricity, so far as can be ascertained up to the beginning of last month. Of these, 209 employ plant and apparatus for the generation and supply of continuous currents, 39 are designed on the alternating-current system, whilst seven possess appliances suited to both methods. Besides the grand total of stations already at work, there are 68 now being constructed, or very shortly to be undertaken. Nineteen have been put into operation since the beginning of the year, being a proportional increase of 7½ per cent. The total power available in these 255 stations, which, by the way, do not include the Parisian "sectors," is approximately 30,800 h.p. The price of current when taken under contract is about £1 for each 8-c.p. lamp per annum, the light being available from sunset to sunrise; but a rate of 35f. to 38f. (say, 28s. to 30s.) is by no means uncommon. When supplied by meter, the lowest rate is 30c. (say, 3d.) per unit, the average price being 90c., or 9d. Consumers prefer, however, to an increasing degree to take their current by meter rather than under contract.

Fowler-Waring Cables.—A copy of the new issue of the catalogue of the Fowler-Waring Cables Company, Limited, of 32, Victoria-street, S.W., has been forwarded to us. The types of cables made by the company are well known, and they are used by, among others in this country, the London Electric Supply Corporation and the City and South London Railway. Of the new features in the present edition may be mentioned the many illustrations of different kinds of junction-boxes and fittings for lead-covered cables, and which have been extensively adopted. It is usual to make the boxes of cast-iron, but gunmetal is used for exceptional positions. Some of the boxes have the connection to the cable made through a watertight screwed gland, whilst others are fitted with a brass tube

which is plumbed to the cable by a wipe joint. The company, however, recommend a connection where a tinned solder pocket surrounds the cable, and which when filled unites the metals and is absolutely watertight. The introduction of the junction boxes has in a large measure been the means of overcoming the difficulty first experienced in the jointing of the mains and in distribution from them. The company have brought out a system of concentric conductors and fittings, which are fully described and illustrated in the catalogue, and which has been largely adopted in this country and abroad. Telephone cables of both the solid and dry core type are described at length, together with illustrations. The catalogue is well got up and should be in the hands of all electrical engineers.

Water Power for Central Stations.—One can hardly take up a single number of any continental electrical trade journal without finding details here and there, paragraph after paragraph, and article upon article, respecting the use of water power for the economical generation of electricity—whether to light up houses and streets, or operate an electric tramway, and other such purposes where the electric motor is required. The number and importance of these natural power resources are so great that an English central-station engineer almost feels his mouth watering when he vainly sighs for such ready means of obtaining a cheap supply of power to drive his generators. Take, for instance, the details given in another note with respect to the total number of central stations now actually at work in France: of the 255 there mentioned, no less than 155, or, say, three-fifths, are operated either wholly or partially by means of hydraulic power; and this fact leads to the very curious result that very often it is the small towns—and even villages—which are able in this way to avail themselves of both public and private electric lighting long before some of the most important cities and large towns advance to a similar position. Probably very few of our readers have ever heard of Saint Didier-la-Seauve. This is an unimportant place of only 5,000 inhabitants, yet it has a water-power plant, driven by a 19ft. 6in. fall in the river, giving about 40 h.p. From this station current is supplied for lighting at 7½d. per unit, or by contract, according to the purposes for which the the building is designed—cafés and restaurants, about 30s.; shops, 25s.; apartments, 20s.; offices, 17s., per annum for each 8-c.p. lamp. Lamp renewals are undertaken at a fixed rate, slightly under 2s. per lamp per annum. Motive power is supplied at from £4 to 36s. per horse-power per month, according as the power of the motor is less or more than 5 h.p.

Accumulator Cars in Paris.—It looks as if Paris would demonstrate the practicability of running accumulator cars on a practical scale before London after all. The St. Denis lines of two routes, each six miles long, are both worked on this system, and another line of three miles is to be added. M. Max de Nansouty, in *Le Génie Civil*, gives (Vol. XXII., p. 197) details and illustrations of the cars used. Each car seats 50 passengers, and travels at 7½ miles an hour, with an increase to 10 miles per hour outside the fortifications, with a minimum speed of 3¾ miles per hour on the steepest gradient of 4 in 100. The weight of accumulators is 2·6 tons. The car bodies rest on two truck frames each with one axle and a separate motor which is geared to the axle by two sets of geared wheels, the angular velocity of motor and axle being as 12 to 1. The motors are of the Manchester two-pole type excited in series, and each capable of developing 10 kilowatts at 200 volts for 1,350 revolutions. The efficiency between motor terminals and axle is given as 73 per cent. Laurent-Cely cells are employed in a battery of 108 11-plate cells, which are charged by Desrozier dynamos. The batteries have an efficiency of 70 per cent. They give a maximum of 70 amperes or 1·8 ampere per lb. of active material at an E.M.F. of over 200 volts. The average discharge current is 35 amperes. Each set of cells will take a car 40 miles on grooved rails or 75 miles on vignole rails—a fact that speaks loudly for the latter. The battery is divided into four groups enabling either 50 or 200 volts to be used to obtain varying speeds. The motors are usually connected in series, but may be connected in parallel for greater speed or power. Backward or forward running is obtained by reversing the current in the fields, and either motor can be cut out in event of accident. The weight of a loaded car is 13½ tons of which 2·6 is for cells and 3·5 tons is for passengers. The cars make eight or nine double journeys per day, corresponding to a distance of 92 or 104 miles, as against 62½ for the horse cars.

Simultaneous Contrast Colour.—A paper is given by Mr. Alfred M. Mayer (*American Journal of Science*, July) on the phenomena of contrast colour, and on a photometer for measuring the intensities of lights of different colours. A ring is formed of white cardboard by cutting an opening from a disc. Another ring is made with narrow radial arms to support a larger disc of white linen tracing-paper. The disc is stretched and screwed between the rings, and the whole mounted on a stand. The screen so formed is placed in front of a petroleum lamp, and the daylight is excluded from the side thus illuminated. The other side is illuminated by the light of the sky from a distant window. The cardboard ring is thus illuminated on one side by the lamp and on the other by the daylight. The translucent paper transmits the lamplight to the side facing the window, while it transmits daylight to the side facing the lamp. On the side of the screen facing the window the cardboard ring appears cyan-blue, while on the side facing the lamp the ring appears orange. The intensity of the colours will excite astonishment even in the minds of experimenters in colour contrasts. The colours are complementary. The author made some experiments on simultaneous contrast colours produced by the electric flash. In the case of the discharge of a large induction coil, the author had shown (*American Journal of Science*, December, 1874) that when the striking distance between brass ball electrodes is only one millimetre, with a Leyden jar of 242 square centimetres of surface in the circuit the discharge lasts $\frac{1}{24}$th of a second, and is formed of over 120 separate sparks, but as the striking distance is increased the discharge is formed of fewer and fewer components, till at one or two centimetres the discharge is a single flash. In the experiment the striking distance was 8cm., and a single flash was given whose duration may be safely taken as less than one-millionth of a second. In a dark room the flash gave vivid contrast colours, the grey ring appearing bright pink on an emerald green ground and of bright yellow on an ultramarine ground. The author investigates the period of time necessary to distinguish the colours and form a judgment on them. It is less than $\frac{1}{7}$th second. These contrast colours are used by the author in a photometer disc to compare lights of differing colour. Two circular discs have eight sectors cut out, and between these was placed a circle of white translucent tracing-paper. A black disc covered up most of the central part, leaving alternate squares of cardboard and translucent paper round the rim. Experiments were made to test this apparatus as a photometer. The disc was rotated opposite mirrors inclined at 150deg. One side illuminated by daylight appeared white tinted yellow, and the other side facing the lamp appeared white tinted blue. To bring these to the same hue, a compound disc was

placed on the daylight side formed by three split discs of red lead, chrome yellow, and white cardboard. On the lamp side a disc of three split discs of ultramarine, emerald green, and white. On rotation, these combinations gave orange-yellow and bluish-green respectively, and the contrast effect of these brought the light in the translucent part to the same hue on both sides. The apparatus is used as photometer with very good effect.

Electric Eels at the Zoo.—A series of experiments has been conducted at the Zoological Gardens by the naturalist contributor to the *Spectator* on a couple of electric eels, with remarkable results. "The largest of the pair, about 4½ft. in length, thick and deep, and probably weighing from 16lb. to 18lb., was moving sluggishly on the bottom of the tank, and was slowly raised to the surface by a landing-net.. When grasped in the middle of the back there was just time to realise that it had none of the 'lubricity' of the common eel, when the first shock passed up the arm with a 'ticker' identical with that which a zigzag flash of lightning leaves upon the eye, and, as it seemed, with equal speed. A second and third felt like a blow on the 'funny bone' and the hand and arm were involuntarily thrown back with a jerk which flung the water backwards on the pavement and over the keeper who was kindly assisting in the enterprise. This slight mishap recalled a far less agreeable result of a shock inflicted on a previous enquirer, whose recoiling hand had struck the assistant a severe blow in the face. Unwilling to be baffled by a fish less in size than the salmon which form the common stock of a fishmonger's window, the writer once more endeavoured to hold the eel at any cost of personal suffering. But the electric powers were too subtle and pervading to be denied. The first muscular quiver of the fish was resisted, but at the second, the sense of vibration set up became intolerable, and the enforced release was as rapid and uncontrollable as the first. The smaller eel was neither so vigorous nor so resentful as its fellow. But a third shock was equally intolerable with that given by the larger fish. The electrical power seems to increase rapidly in the heavier eels. One of 5ft. in length, which appeared to be nearly dead when it arrived at the gardens, and was therefore handled without ceremony, inflicted a shock which, as the keeper stated, 'nearly sent him on his back.' This power of projecting its electric discharge, either through the water or by means of any conductor, to the object which it desires to paralyse, may well be observed at the Zoo. It is when in pursuit of the small fish which form its food that the 'range' of the eel's battery is best seen. On the last occasion on which the writer was present at the eels' feeding hour, eight or ten lively gudgeon were taken from a pail and placed in the eels' tank. The small fish at once dived to the bottom, as is their habit, and sought refuge at the corners, or at the angle made by the meeting of the base and sides of the stone cistern. Everyone of the fish was killed by electric shock before being eaten, but in the case of those in the corners it was impossible for the fish to bring the electric organ, which lies on each side of the lower part of the tail, into direct contact. The eel, therefore, swam past them like a torpedo boat which intends to discharge its broadside torpedoes, and as the battery came opposite the fish gave a slight quiver, which instantaneously produced a violent shock in the gudgeon, and turned it belly upwards. One fish which was shocked and left for dead while the eel went in pursuit of more, recovered after a few minutes, and was subsequently pursued, received a direct shock from the eel's side and was killed. The inference suggested by the writer's own experience of the violence of the shocks inflicted, though with different degrees of intensity, is that the eel controls the power of the electrical discharge at will, and that the gudgeons received enough, and no more, than was sufficient to paralyse them, and make them easy victims for the slow-moving eel."

New Method of Heating. M. Jules Neber, writing in the New York *Electrical Engineer*, July 12, with reference to the new method of electric heating by plunging a metal electrode into an electrolyte, says he has experimented on the same subject in the Westinghouse laboratories, and his experiments lead to a somewhat different explanation of the heating effect. It has been said that the resistance of the coating of hydrogen generated round the iron is sufficient to produce the heating. But in one of his experiments he sent 300 amperes at 125 volts without obtaining any considerable heating of the iron—the total energy being consumed by electrolysis of the water and heating of the electrolyte. But this was when the iron cathode was immersed before the current switch was closed, so that the hydrogen coating was present but effected no heating. By closing the switch *before* immersing the iron the whole experiment is changed. The moment the iron touches the water the amount of hydrogen generated separates the liquid from the metal, and an arc is drawn. The effect is more brilliant if an insulated wire is used so that an arc is produced at one place only, and wholly under the surface. The apparatus used was a glass jar 8in. high and 5in. diameter, filled with water containing 25 per cent of sulphuric acid. The positive pole consisted of a ⅛in. sheet lead cylinder, the edges standing apart about 2in. to allow the inside of the cell to be seen. The iron cathode consisted of a ⅜in. round iron bar, connected to the dynamo cable and fastened to a wooden stick. Several tests were made. With 20 amperes at 150 volts, a weight of 15 grammes of wrought iron was brought to melting heat in 15 seconds, the iron actually dropping down to the bottom of the jar (which was protected by a disc of lead). In 15 seconds 15 grammes of iron were raised 2,000deg. C., and 1,500 grammes of water 3deg. C. The heat employed in the melting of the iron is 2,000 (deg.) × 15 (grammes) × 0·1,138 ÷ 15 (seconds) = 250 gramme-calories corresponding to 1,048 watts; in the water 3 × 1,500 × 1 ÷ 15 = 300 gramme-calories, or 1,257 watts, and the power consumed in electrolysis equals 20 amperes × 1·5 volts (counter E.M.F.), or 30 watts, making a total of 2,335 watts accounted for out of 20 × 150 = 3,000 watts. There is still 665 watts equal to 159 gramme-calories to dispose of for radiation and conduction, which is about equal to 29 per cent. of the heat utilised in iron and water heating. The efficiency is thus approximately (for the calculations cannot be considered exact) 35 per cent., as 1,048 of the 3,000 watts are utilised in heating the iron. Other metals, as copper and lead, are melted quicker or slower, according to their conductivity for heat. Carbon is heated in a very short time, but the melting off of amorphous carbon, as reported by the Belgian experimenters, could not be obtained, and the authenticity of this phenomenon is doubted. It is to be noticed that using a low E.M.F. as 100 volts the heating is scarcely perceptible, though the current is about the same, probably because the arc is not long enough; 125 volts seems the critical voltage. By changing the poles oxygen is obtained in the iron cathode, which causes explosions in combining with the hydrogen chemically developed by the contact of the iron with sulphuric acid. The practical advantages of the process, says the author, is undoubtedly in the total absence of oxidation of the heated metal, and this feature might probably lead to an extensive use of the process. For the experimenter the phenomenon of wrought iron melted like wax in a glass jar filled with water is one of the most striking imaginable.

THE PREVENTION AND CONTROL OF SPARKING.*

BY W. B. SAYERS.

In the course of the discussion upon my paper dealing with the control of sparking in short air space dynamos, Mr. A. P. Trotter and several other gentlemen suggested that I should give some definite information about the relative cost and efficiency of a machine on my principle, compared with an ordinary smooth-core machine. In complying with these requests it seemed to me that I could not do better than compare a machine of my design with the Edison-Hopkinson machine, which was described in the celebrated paper on "Dynamo-Electric Machinery," by Drs. J. and E. Hopkinson, read before the Royal Society in 1886.

The particulars of the Edison-Hopkinson machine given herein are partly taken from Dr. S. P. Thompson's "Dynamo-Electric Machinery," and partly from specimens of the machine, several of which I have had experience of from time to time. There is no sparking whatever at the brushes of this machine when working at full load, and I believe the limit of output is fixed by the heating and by the mechanical strength of the armature. I have, therefore, in my design kept the total magnetic flux through the armature, and also the magnetic density, the same as in the Edison-Hopkinson machine.

The total flux through armature core when the machine is running without load is about 10,530,000 C.G.S. units.

The E.M.F. is generated by 20 coils in series, which cut the field of force four times per revolution. We have, therefore, if we take the speed at 750 revolutions per minute,

$$E = \frac{10{,}530{,}000 \times (4 \times 20) \times 750}{60 \times 10^8} = 105 \text{ volts.}$$

FIG. 1.

In my design I make the number of coils on the armature 38, and the E.M.F. is generated by 19 coils in series and two "commutator coils," or "reverser bars," as I prefer to call them in a machine of this size, because they only pass once from end to end of the armature, without going round the ends. The two reverser bars add an E.M.F. equal to one main armature coil, because, although the E.M.F. induced in one of them is only half that induced in an armature turn, they carry the whole current, and thus add their half-turn E.M.F. to both halves of armature. Thus we have

$$E = \frac{10{,}530{,}000 \times \{4 \times (19 + 0{\cdot}5 \times 2)\} \times 750}{60 \times 10^8} = 105 \text{ volts.}$$

The diameter of the new armature over all is $11\frac{1}{4}$in.; at the bottom of the tunnels, $9\frac{1}{4}$in.; and of the hole through the centre, 3in. The length of the core is 20in. The area of the iron in the core of the armature is thus, allowing 5 per cent. for paper,

$$20 \times (9{\cdot}25 - 3) \times 6{\cdot}45 \times \frac{95}{100} = 768 \text{ square centimetres.}\dagger$$

The induction density in the armature core will be

$$\frac{10{,}530{,}000}{768} = 13{,}700.$$

* From the *Journal* of the Institution of Electrical Engineers.

† The area of iron of core of armature of E H machine is given in Dr. Thompson's book as 810 square centimetres, but apparently this has been reduced, as the cores of two armatures which I have had the opportunity of measuring have only had a section of about 770 square centimetres of iron, excluding the three discs of ¼in. thickness which are in the Edison-Hopkinson armatures.

The air space I make 0·25 centimetre, or about 0·1in. The tunnels are shown full size in Fig. 1; they are 0·125in. below the surface, 0·875in. deep, and 0·437in. wide. The crown of the tunnel is slotted through to lessen the self-induction of the conductors.

The main winding would be of rectangular conductors 0·3in. × 0·25in., and the "commutator coil," or reverser bar, 0·3in. × 0·15in. These conductors and the tunnels

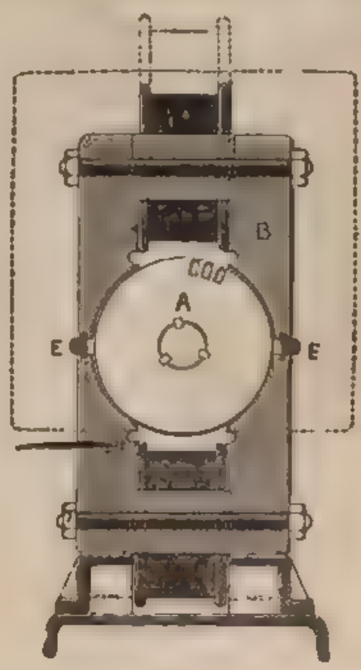


FIG. 2.

which contain them are shown in section, full size, in Fig. 1. The main conductors, C, may advantageously be made up of eight wires of rectangular section, covered together so as to form a stranded conductor. The object of the stranding is to facilitate bending. The current-density at full load of 320 amperes will be 2,150 amperes per square inch, against 2,460 in the Edison-Hopkinson machine.

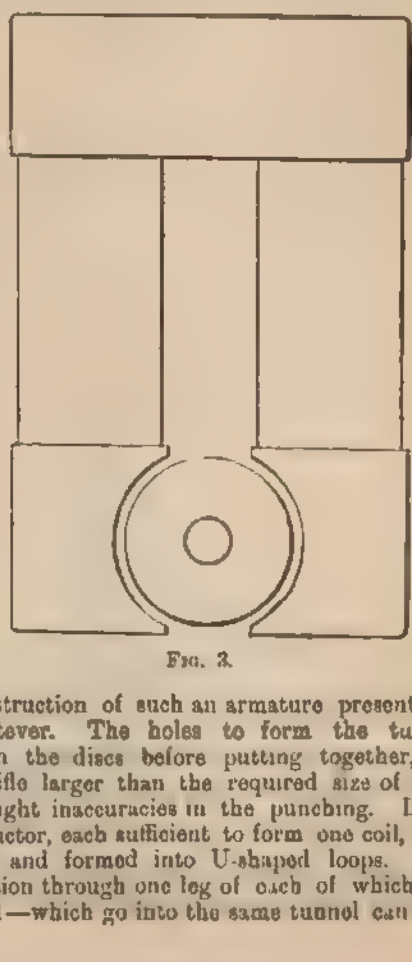


FIG. 3.

The construction of such an armature presents no difficulty whatever. The holes to form the tunnels are punched in the discs before putting together, and are made a trifle larger than the required size of tunnel to allow of slight inaccuracies in the punching. Lengths of main conductor, each sufficient to form one coil, may then be cut off and formed into U-shaped loops. The two loops—section through one leg of each of which is shown at C, Fig. 1—which go into the same tunnel can be taped

together, and the reverser bars—section of one of which is shown at D, Fig. 1—with them, and then slid in from the commutator end. When all the U-shaped loops are in position, their free ends may be bent and connected up in the same manner as that adopted in the Edison Hopkinson armatures, so as to form the main winding; but instead of soldering the ends of the coils into the commutator lugs at the time of connecting up, as is done in the Edison-Hopkinson armature, the ends of the reverser bars can be soldered to the points of connection between the coils at the same time as they are connected up. The reverser bars run back through the tunnels to the commutator. Fig. 2 represents in section at right angles to shaft the new design. Fig. 3 represents the end view of iron only of Edison Hopkinson machine, to same scale.

The dotted line in Fig. 2 indicates a single-limb magnet. A great additional saving of weight, however, is obtained by making a double magnet, as shown in full; and the value of the iron saved more than covers that of the additional wire required. The top and bottom halves of the magnets are separated by four brass distance pieces of the section shown at E. These may be, say, 3in. long, and placed one at each corner of the magnet limbs; gaps will thus be left for ventilation. Below are given the comparative electrical data, weights, and values of material in the two designs.

ELECTRICAL DATA.—*Armature.*

—	Edison-Hopkinson.	Sayers.
Cross section of conductor..	0·065 sq in	0·075 sq. in.
Current density	2,460 amps. per sq in.	2,150 amps per sq. in.
Resistance at 100deg F.	9·008 ohm.	0·0067 ohm.
„ of two reverser bars.	—	0 001 „
Total resistance between brushes	0 008 ohm.	0 0077 „

Field Magnets.

Resistance of magnet coil.	Edison-Hopkinson.	Sayers.
Say 15,000ft. No. 13 wire	16·93 ohms.	—
If single magnet, 14,000ft. No. 19 wire	—	82 ohms
If double magnet, 14,000ft. No. 17 wire	—	43 „
Current	6 amperes.	—
If single magnet	—	1·28 amperes
If double magnet	—	2 56 „
Ampere turns in shunt coils	19,600	3,600

WEIGHTS AND VALUES.

—	Edison-Hopkinson.			Sayers.		
	Weight.	Rate.	Value.	Weight.	Rate.	Value.
			£ s. d			£ s. d.
Armature discs.	3·7cwt.	32s.	5 18 0	4·7 cwt.	32s.	7 10 0
Armature conductor	60lb.	9d.	2 5 0	67lb.	1s.	3 7 0
Reverser bars .	—	—	—	11 5lb.	9d.	0 8 8
Magnet cores	31·7cwt.	12s.	19 0 0	12 2cwt.	12s.	7 6 0
Magnet wire .	410lb.	9d.	15 6 0	141lb.	10d.	5 17 6
			42 9 0			24 9 2
Total weights of parts enumerated above	39·5cwt.			18·8cwt.		

There will be a further saving of weight of material in the bed-plate on account of the lighter magnets; and if required compound-wound, the whole cost of material and labour for this will be saved, as the new design will "compound" without any series coils.

As regards the cost of workmanship, so much depends on the details of the design, and the means employed for performing the various operations, that I think it would hardly serve any useful purpose to give my estimate for these.

In addition to the saving in weight and cost of materials, I must claim for the new design great superiority from a mechanical point of view. Each disc of the armature is positively driven by the three keys upon which it is supported; the conductors are positively driven—whether or no there is any force exerted upon them; and the armature presents a smooth iron surface which is not liable to damage from careless or unskilful treatment. The space left for insulating material in Fig. 2 is ample for 100 volts, as I have proved by considerable experience: the normal insulation resistance to the iron in such an armature would be two or three megohms. If a much higher voltage were required, the tunnels would be made deeper, so as to provide space for additional thickness of insulation, the diameter of the armature being increased to allow of the deeper tunnels.

DESCRIPTION OF THE ELECTRIC ROCK-DRILLING MACHINERY AT THE CARLIN HOW IRONSTONE MINES IN CLEVELAND.*

BY MR. A. L. STEAVENSON, OF DURHAM.

Ironstone mining in Cleveland has now extended over a period of 40 years, during the whole of which the writer has been connected and conversant with its progress.

Mining by Hand Labour. Hand labour has been the general custom, and during the first 25 years, when skilled men were scarce and new comers had to learn the work, it was usual for a skilled miner to take a novice as an underhand with him to break up and fill the stone, paying him a datal wage varying from 3s. 6d. to 4s. per shift. These underhands were known amongst the miners as "hagmen." The skill of the miner being exercised in getting as much stone with as few holes and as little powder as possible, the holes are drilled of a three-cornered section by the miner giving the drill a slight turn between each blow of the hammer; they vary from 3½ft. to 4½ft. in depth, depending upon the backs or natural vertical cleavages in the stone. To drill a hole of 3½ft. requires about half an hour of steady work; the powder used is about 6oz. per ton of stone, and the usual price of getting from 10d. to 1s. per ton. Gradually, as the supply of skilled men overtook the demand, the two miners in each place shared the work and money between them, each man making 4s. 6d to 5s. 6d per shift.

Hand-Ratchet Drill.—During the last few months hand drills made to revolve by a ratchet have been introduced, the work being divided between the skilled miner and the filler. These drills promise good results in cases were machines are not available; but the question of prices is not yet definitely decided.

Compressed-Air Rotary Drill.—About 16 years ago Mr. William Walker, of Saltburn introduced a rotary drill worked by compressed air. Of these the writer procured four; and by working double shift, and employing one skilled man to work the drill and another to fire the shots, with unskilled labour to do the rest, he has effected considerable economy. At the Skelton Park Mines of Messrs Bell Bros. these machines continue doing good work. The writer has always insisted upon the necessity for adopting the Colladon system of cooling the air by water spray during compression; but notwithstanding the marked economy resulting therefrom, the great leakage, arising from the length of pipes of various sizes, which amounts in this case to about eight miles, and from the consequent large number of joints, seemed to present an opportunity for improvement by the use of hydraulic power.

Hydraulic Drill.—At the Lumpsey Mines, therefore, where there was a large body of water tubbed back in the shafts 600ft. deep, the writer designed a hydraulic drill to utilise this water, carrying pipes in to the face of the working places. The pressure of 250lb. per square inch at the shaft bottom was utilised at the drill by means of a small turbine made by Messrs. Gilbert Gilkes and Co., of Kendal, and placed on the machine. This plan has given excellent results; but, as the water has to flow back to the shaft bottom, it can only be used in places to the rise; and moreover it involves the cost of water mains to convey the pressure.

Petroleum Engine.—The writer next introduced the petroleum engine of Messrs. Priestman, and a drill suited to its conditions. Five of these are now in use, and have done good work.

Electric Drill.—When electricity became applicable, its simplicity and regularity in working seemed to offer an inducement for a trial. With the assistance of Mr. Robert Clough, engineer to the mines and collieries of Messrs. Bell Bros., the writer designed a drill to be worked by this power.

Dynamo.—The current for working the drills is generated at bank by a compound wound dynamo, having an output of 20,000 watts, and capable of furnishing a current of 50 amperes at a pressure of 400 volts, when running at 900 revolutions per

* Paper read before the Institution of Mechanical Engineers. Communicated through Sir Lowthian Bell, Bart., Past President.

minute. This dynamo is intended to supply current for working the first section of the plant—namely, three drilling machines. The current required to drive each drill varies, of course, with the hardness of the stone the drill is working in; but it may be taken that under ordinary conditions, and when the voltage at the drills is 300, the current absorbed per drill motor is about 15 amperes, which is about 6 e.h.p.; and when a dynamometer was applied to the drill bar, 6 h.p. was obtained. The current from the dynamo is taken to a high tension double-pole switch on the main switchboard, which is of enamelled slate, and has mounted upon it the necessary fuses, measuring instruments, etc.

Cable and Junction Boxes.—From the switch the current is conveyed down the pit through cables covered with highly vulcanised indiarubber. The cables are run all the way in bye on insulators, and are kept well in sight, so that should a fall of stone occur, the damage can be quickly discovered and set right. The main cables are run to a point at a distance of 1,000 yards from the generator, and then from this point branch cables are run to the different junction-boxes, of which there are six to each drill, commanding 12 working places. The junction boxes were specially designed to meet the exigencies of the case by Mr. Bigge, and are really a combination of a junction box, switch, and connecting plug. The plug is locked in position by a pin, and cannot be withdrawn without first of all lifting the switch, thus preventing sparking and wear on the contacts. Each district to be worked by the several drills is completely wired out and fitted up with these junction-boxes, so that when the drill is moved from one working place to another a box is always to be found within 50 yards distance. The plug at the end of the drill cable is then inserted, the switch on the drill turned on, and within a few seconds the drill is again at work. Much time is saved by this method.

Drilling Machine.—Drawings, half full size, showed that the way in which the electricity is applied is neat and handy. The motor is used not only to drive the drill gear, but also to act as a counter-balance to the weight of the drill itself and its gearing. The motor rotates a shaft, which passes through the long hollow carrying-bar, and by a pair of bevel wheels causes the vertical spindle to revolve; and a bevel pinion on the top of the spindle, gearing into a bevel spurwheel on the boring-bar, rotates the drill. The forward feed of the boring-bar is governed by two pairs of retarding wheels, which are geared in such a proportion as suits the nature of the stone. The drill is carried on a circular bed plate, which is mounted on the end of the carrying-bar and can be turned round by hand when the binding screw is released. As soon as a hole has been drilled the full length of the screw on the boring bar, a split nut is opened, and the boring bar drawn back for inserting a longer drill. In order to reach different heights, the drill can be tilted upwards or downwards by means of a semi-circular arc, which is moved by a worm. By another wormwheel an upright pedestal can be turned horizontally round its centre. A third wormwheel turns the long hollow bar which carries the drill.

Motor.—The motors on the drills are shunt-wound, and can easily utilise a current of 20 amperes at 300 volts pressure, giving off about 95 per cent. of what they receive. They are of the Goolden enclosed kind for mining purposes, both the armature and the commutator being completely enveloped in gun-metal cases, which are both gas and dust tight. Even should water pour over them, or a fall of stone occur, they are perfectly protected, and no appreciable damage would be done them. The brushes used are of special carbon coated with copper. The feed for the brushes as they wear themselves away is automatic, so that they can be run for weeks together without requiring any adjustment or attention. Each drill is provided with a starting switch, placed in the most convenient position on the drill carriage itself, and arranged with resistance coils in such a manner that the drill can be started gradually, and stopped either gradually or instantaneously. Each drill is also provided with a reel of 50 yards of twin flexible cable for the supply and return of the electricity; at the end of the cable is a connecting plug for inserting into the nearest junction box.

Working.—These electric drills were put into the hands of men who had no previous knowledge whatsoever of electricity, and the day the first drill was put into the mine it was at once set to work at the face, and has been at work ever since. The men are now thoroughly accustomed to the drills, and handle them with the greatest ease. The writer has thus tried almost every method for working drilling machines in ironstone mines, including compressed air, hydraulic power, and petroleum engines, and it is his decided opinion, as the result of this practical experience, that for simplicity in working, ease of transport, speed, facility for extensions, and economy in working, the electric drill has proved itself to be in advance of any other mechanical contrivance yet introduced, and that in the future, where power has to be conveyed to any considerable distance for mechanical drilling, electricity will undoubtedly play the predominant part. The entire work was placed in the hands of Messrs. D. Selby Bigge and Co., electrical engineers, of Newcastle-on-Tyne, and Mr. Bigge devoted considerable time with the writer and Mr. Clough to working out and improving the various details of this the first attempt at electric drilling in the Cleveland ironstone mines.

Output.—The joint output for one week for two of the three machines has already reached 1,577 tons with 790 holes. From 80 to 100 holes have frequently been bored by one machine in a shift, each hole averaging about 4½ft. deep. The miners are enabled to earn 7s. 7d. each per shift, while the stone is got at a cost of 7¼d. per ton. Powder is always from one-third to one-half more costly when drilling machines are used than is the case with hand labour, since it suits better to blow the stone out with a larger number of holes which are quickly and cheaply drilled; this plan also makes the stone fall in smaller blocks, and so saves labour in breaking them up previous to filling.

General Results.—In attempting to compare the results obtained with the several drills, the following considerations have to be borne in mind. The conditions of the seam of ironstone affect the output and cost. An open stone admits of fewer holes in one place. Then time is lost in more frequent removals of the drill, and the number of holes drilled per hour is diminished.

The cost of the machine itself sometimes represents the whole and sometimes only a fraction of the total cost. Thus a petroleum drill covers the entire cost of its adoption. But the compressed-air drill in some cases has attached to it an average of more than a mile of pipes, and also requires its engine and compressors, as well as its share of boiler. The electric drill also requires engine and dynamo, with a length of cable depending upon the distance from the shaft; it is still so new that alterations and improvements are being made as experience is gained. The hydraulic drill, although getting its power from natural sources, needs pipes, and the exhaust water has afterwards to be pumped up to the surface. The hand ratchet-drill has been applied as yet in only one or two mines, and the tonnage rates and system of working are not yet finally settled with the workmen.

Subject to these considerations the following comparative statement may be taken to represent generally the results thus far obtained with the several drills.

Description of drill.	First cost of machine only. £	Holes drilled per hour *	Ironstone got per shift. tons.
Hand jumper . . .	— ...	4½ft. in 45min. ..	5 to 8
Hand ratchet drill	3	not yet known ...	about 18
Compressed air drill	250 .	about 8 holes .	100 to 130
Hydraulic turbine . ..	220	„ 8 „ .	100 to 130
Petroleum engine .	375	„ 8 „	100 to 130
Electric drill	350 .	„ 10 „ .	140

* This includes the time lost in moving the machine to different working places.

The length of shift is eight hours from bank to bank, or say seven hours at the face. At the Park Mines the drills work two shifts in 24 hours, and at other mines one shift; and six shifts per week when trade permits.

ON THE ELECTRIC LIGHT OF LIGHTHOUSES.*

EXPERIMENTS MADE BY THE LIGHTHOUSE DEPARTMENT OF FRANCE.

BY ANDRÉ BLONDEL.

(Continued from page 91.)

CONTINUOUS-CURRENT DYNAMOS: THEIR PROPERTIES AND THE RESULTS THEY GIVE.

In order to construct a machine with two fixed *régimes*, say, of 25 and 50 amperes, we may adopt either a winding with two distinct circuits, capable of being used separately or together, or a simple winding, altering the current either by means of the exciting current or by the introduction of a resistance in the circuit. The properties of the machine and the choice of the system to be adopted depend essentially on the method of exciting.

Shunt-Wound Dynamos.—Exciting in shunt is produced, as we know, by the aid of a circuit of fine wire wound on the electro-magnets, and connected either to the brushes or to the terminals of the machine. The shape of the characteristic is in some respects of advantage; on short circuit the intensity, far from becoming dangerous, is reduced to zero; as a consequence there is no pulling up of the motor at starting. But it is difficult to realise in, on normal *régime* the desired slope without approaching too near the limit of demagnetisation; it is then almost a necessity to employ in addition a small rheostat.

A trial of a machine of this type was made at the lighthouse establishment in 1892 with the current of 25 amperes. The working was satisfactory, a rheostat being added; but the machine became

* Paper read before the International Maritime Congress, London meeting, July, 1893.

given by M. Allard* is only applicable to arcs of very small length. It would probably be suitable to the arc light of St. Catherine (Isle of Wight), the separation in which is not more than ½mm., and the pressure only from 35 to 38 volts. With an arc so short, almost always on the point of sticking together, the surfaces of maximum brightness are almost completely shaded by the carbons, and it seems hard to believe that the highest efficiency could be realised in this way, as some have asserted.

In France it is preferred to employ a genuine arc, with a pressure of 45 volts, corresponding to a separation of 4mm. to 5mm. for the current of 25 amperes, and exposing the bright surfaces. The part played as a lighting agent by these is then shown by the curve of light-distribution, which assumes the appearance of a butterfly, Fig. 8, giving maxima in directions having an inclination of 45deg., the superiority of which over the horizontal intensity becomes more marked as the separation is made greater.

Intrinsic Brightness.—It would seem that the maximum intrinsic brightness ought to be less than in the case of the continuous-current arc, since each surface only acts as a positive pole during one alternation in every two, and even less, and can thus cool during the remainder of each period. As a matter of fact, this is the case with arcs of very small activity (8 to 10 amperes). But in those of 25 amperes and upwards, the period of extinction being very short, and each crater being smaller than the average intensity would require, the measurements made with the Le Chatelier pyrophotometer at a frequency of 50 have not shown any appreciable difference. The maximum brightness does not even vary to any extent with the intensity or with the separation. But the same reservations as in the case of the continuous current, must be made as far as the average brightness is concerned.

Practical Effect with Different Currents.—To appreciate the ultimate effect in the optical apparatus, we come back then once more to the question of occultations. The bi-focal arrangement devised by Inspector General Bourdelles, which consists in placing the focus of the dioptric drum, Fig. 9, at the centre of the incandescent part of the lower carbon, and the focus of the catadioptric rings at the centre of the incandescent part of the upper carbon, theoretically allows of nearly all the focal rays of the apparatus, Fig. 9, passing by the surfaces of maximum brightness. But in practice this maximum efficiency is not realised, owing to inevitable occultations, and to an effect analogous to that already pointed out in the case of continuous currents. The power of the pencil still increases with the intensity of the current, as is shown by the following table, which I borrow from the paper already quoted, only adding the column of true efficiencies.†

Diameters of the carbons.	Amperes.	Volts.	Apparent watts.	True watts.	Carcels of 10 candles.	Efficiency per watt.
10	25	45	1,125	1,070	1,200,000	1,120
16	50	45	2,250	2,140	1,800,000	840
25	100	45	4,500	4,275	2,300,000	512

The explanation of this phenomenon might be sought in the same causes as in the case of continuous currents. However that may be, as the luminous power only increases slightly in comparison to the expenditure of energy, there could be no advantage in going farther in this direction, and it would be preferable, in accordance with the curious observation of M. Bourdelles,‡ to unite several lights of small intensity in separate lenses.

However, if we have to employ later on lenses of greater diameters (third, second, and first order), the period of brightness being less than the maximum time of perception,§ all the light would be utilised, and even admitting that the brightness would remain the same, there would be an advantage in increasing, within certain limits, the power of the arc.

(To be continued.)

TRADE NOTES AND NOVELTIES.

STONEWARE CONDUITS.

A new type of conduit for underground mains has been brought out by Messrs. Doulton and Co., and has been on view this and last week at their showrooms, Albert Embankment, Lambeth, S.E. The conduit, which we illustrate herewith, is made of highly vitrified stoneware, and of rectangular and circular form. It is made in lengths of 3ft., and with two or more separate ducts or ways. There are several methods of joining the lengths of casing or conduit: one plan is shown in Fig. 1, which is a cross-section at the joint of a three-way conduit. In this case the ends of the casing when brought together are lapped round with a band of prepared canvas and enclosed in a stoneware trough open at the top. Before being placed in position, the lower interior surface of the trough receives a layer of Portland cement, which cannot enter between the casings owing to the canvas band. The next operation is to fill the trough to its upper edge with cement, and by this means it is possible to rapidly make a reliable joint.

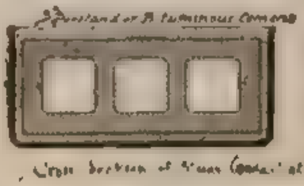


FIG. 1.

In some cases it is necessary to economise space, and under such circumstances another method of jointing may be adopted, as in Fig. 2. This is to substitute a light cast-iron collar or trough for the stoneware trough, adopting the same plan as in the first system, or the trough may be simply filled with bituminous or other cement, the canvas band being also used. For this purpose Messrs. Doulton have prepared a special compound, which forms a very suitable and rapidly-setting cement.

FIG. 2.—Detail of Joint.

The two methods described are sufficient for ordinary requirements, but where it is desired to keep the complete separation of the ducts where the lengths are connected, the joint shown in horizontal section in Fig. 3 may be adopted. According to this arrangement, the lengths of the casing are laid in the collars with a small space between them. Then mandrels with indiarubber heads, as shown in Fig. 4, are introduced in the ducts, and when opposite the joint between the lengths, are expanded by a simple screw arrangement. Molten cement being next poured in, this fills up the space between the casings except where occupied by the mandrels. The cement sets in two or three minutes, and the mandrels are then unscrewed and withdrawn. This plan enables each duct to be kept entirely separate and continuous with a uniform section throughout the whole length of the conduit. This stoneware conduit possesses great strength, tests showing in the case of the rectangular section that it only cracked at 25 tons to the square foot. It is claimed that this type of conduit affords a perfect mechanical protection to insulated cables, that the material is imperishable, and that it is cheap. Messrs. Doulton also show stoneware tubes provided with self-fitting watertight joints, the arrangement being the use of bitumen cast on to the ends of the pipes; also connection boxes as used at Derby and Whitehaven, and improved insulators for bare copper mains. These insulators, instead of being moulded and made separately, are pressed through a die and cut up in lengths, and have been adopted at Oldham and Aberdeen.

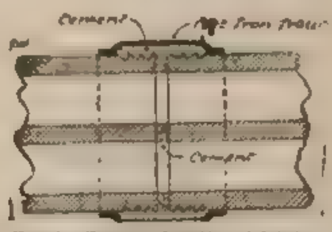


FIG. 3.—Horizontal Section at Joint.

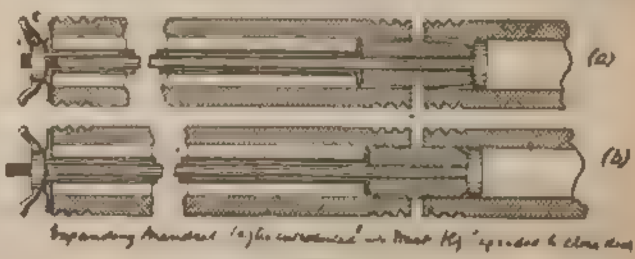


FIG. 4.

* "Memoire sur les Phases Electriques," Plate I., Fig. 4.

† These figures have no concrete meaning, they are merely averages.

‡ See Notice sur les appareils présentés à l'Exposition de Chicago, p. 74.

§ See my paper, "Sur la perception des feux au point de vue physiologique."

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CROMPTON AND CO.

Our financial contemporary, the *Financial Times*, has an article in yesterday's issue entitled "Electric Darkness," criticising a letter sent by the secretary of Messrs. Crompton and Co. in reply to a correspondent. We are not much concerned with the statements in this article, because, if necessary, the whole criticism can be shown to be of the very flimsiest description. If the *Financial Times* desired to criticise a balance-sheet it might do so in the ordinary manner and not through a reply to a correspondent. Mr. Reeves can take care of himself without our aid, but there is a principle behind this action with which we wish to deal. Our reading of the *Financial Times* may be wrong, but its action seems to us to be this: A friend of the paper—whether really an intending investor or not; we imagine not—writes to the secretary of the company before the balance-sheet is out, asking for information in view of investment. Our interpretation is that the authorities of the paper wanted to elicit some information for their own purposes, and not for the purposes of a *bonâ fide* investor, and took this round-about-way of obtaining it, instead of going straight to the mark themselves, where they would have got either a positive or a negative quantity of information. This round-about action, if it exists, puts a secretary into a queer position. He may desire to give a *bonâ fide* investor all possible information, thinking it is information given from man to man, and not intended to be used or seen by third parties. In the particular case under discussion, the secretary referred to the probability of the balance-sheet being somewhat similar to that of the preceding twelve months, but it turned out that there were differences to which the *Financial Times* is not slow to call attention. The reply of the secretary that there had been a large abnormal expenditure during the year, and at the time he wrote it was under discussion to deal with this expenditure in one way while subsequently it was dealt with in another, is a perfect answer to the adverse criticism that he ought to have known at the beginning of July how the accounts ending March 31 stood. He did not know, and yet he did know—that is, he knew the totals, but not the method of disposal, a question the directors had not decided. Was the secretary for the benefit of a fishing correspondent—as proved by the remarks in the *Financial Times*—to give in detail the items of the accounts as made up to March 31, explaining that there had been abnormal expenditure and how it had to be treated was not then settled, or was he to reply to the correspondent in a general way, as in fact he did? Time has shown—at least we think time and the action of the financial critic has shown—that if Mr. Reeves had in confidence given the exact figures at his hand, they would have been used for financial newspaper purposes, and not confidentially by the recipient. There is another point in this critic's lucubration we should like to be noticed—his reference to "ordinary shares" and their treatment in the balance-sheet. What had Mr. Reeves' communication to do with this? He was asked about investing in preference

shares, and, in reference thereto, said, "the report will, I believe, be of a similar nature"—that is, similar to last year—and no doubt had the directors thought well to deal differently with the abnormal expenditure the report would have been similar. Our view of the case is this, that if financial papers want information let them get it in a straightforward manner, and not use ordinary correspondence for their peculiar purposes. Secretaries of companies ought not to be compelled to think before writing letters that the contents may be used for newspaper work, and we will go further, and say that newspapers of any reputation whatever ought to be above using the contents of private letters for their work. In this present case the criticism in this particular direction seems doubly unfortunate. Directors as a rule are not too eager to saddle any one year's revenue with extra expenditure, and if possible will put it to capital account or suspense account, or anywhere not to interfere with the dividend. In this instance the directors took a wiser course and paid the account out of revenue. We think they were right, and commend them for so doing, because we think the concern has more than enough capital to provide dividends for already. If we were to criticise the balance-sheet it would be to argue the general point that no preference shares or debenture stock ought in any concern to carry more than 5 per cent. In reply to this we should be told: you won't get money for any concern under such conditions. Rubbish! Now, as heretofore, most investments for higher dividends than 5 per cent. are risky. This very balance-sheet shows that under ordinary conditions at least 5 per cent. on £275,000 is and can easily be earned, and the path of directors would be smoother if that were the goal rather than a higher percentage on the greater part of the capital and none on the remainder.

EDISON-SWAN.

The balance-sheet of this company given in our last issue, and the report of the meeting as given in our issue to-day, form perhaps the most interesting company history of the year. The chairman directed his attention partly to the future. The period of competition is coming along, patents are about to expire, and it becomes important to the shareholders to ascertain how much, if any, their business will be affected. Our contention with regard to all companies purchasing and working patents is that by law they have given them a close period during which there is no competition, and during which, if the patents are worth anything, a business can be established. An established business is valuable, the value being expressed as good will. A rightly-conducted concern when the patents lapse should have a goodwill as valuable as the cost of the patents, or, rather, as valuable as the amount they stand for in the balance-sheet at the expiration of the patents. The crux of this balance-sheet is the item £242,244—cost of patents, etc. Can this amount in future be charged against goodwill? We think not. It is too high, especially as there is a deferred amount of £117,800 to the same account. Mr. Edison and his colleagues have not taken much out of this company for their nominal holding, they participate in the current distribution of profit, and this is the first time they have participated. The chairman, in his remarks, was cautious in promising participation in future profits by these shares. He hopes they will, but the directors first look to other shareholders. What is the outlook? Throughout the length and breadth of the land travellers for continental firms are offering lamps at 1s. each, as against the 3s. 9d. charged by the Edison-Swan Company. If the company has to reduce its price to a similar amount, its income must be enormously decreased, for we certainly shall not have a sufficient increase in the consumption during the next year to make up for this huge drop. Of course, most people know that the company still controls certain patents relating to holders which makes their position far stronger than if they were wholly dependent upon the lamp patents. Still, with all their advantages, the outlook is far from pleasant, though we agree that within a few years the use of lamps will enormously increase. There is one point to be considered which is generally overlooked that may tell in favour of the company. It is almost certain that no incandescent lamp is made according to patent specification. Improvements in manufacture have been made, and the experience of manufacture should give this company a great pull over their rivals. The lamps offered at these cheap rates have not been tried, and when tried may be found wanting, so that trustworthy lamps will still fetch a higher price, and be eagerly sought after. There are probably some trade secrets not embodied in patents which tend to the making of the better article. It remains to be seen then what the ultimate effect on prices may be.

ON LIGHT AND OTHER HIGH-FREQUENCY PHENOMENA.*

BY NIKOLA TESLA.

(Continued from page 85.)

In these experiments the gas acts in two opposite ways in determining the degree of the incandescence of the filaments—that is, by convection and bombardment. The higher the frequency and potential of the currents, the more important becomes the bombardment. The convection, on the contrary, should be the smaller, the higher the frequency. When the currents are steady, there is practically no bombardment, and convection may therefore with such currents also considerably modify the degree of incandescence and produce results similar to those just before shown. Thus, if two lamps exactly alike, one exhausted and one not exhausted, are connected in multiple arc or series to a direct current machine, the filament in the non exhausted lamp will require a considerably greater current to be rendered incandescent. The result is entirely due to convection, and the effect is the more prominent the thinner the filament. Prof. Ayrton and Mr. Kilgour some time ago published quantitative results concerning the thermal emissivity by radiation and convection in which the effect of thin wires was clearly shown. This effect may be strikingly illustrated by preparing a number of small short glass tubes, each containing through its axis the thinnest obtainable platinum wire. If these tubes be highly exhausted, a number of them may be connected in multiple arc to a direct current machine, and all of the wires may be kept at incandescence with a smaller current than that required to render incandescent a single one of the wires

* A lecture delivered before the Franklin Institute, at Philadelphia, February 24, 1893; and before the National Electric Light Association, at St. Louis, Mo., March 1, 1893.

if the tube be not exhausted. Could the tubes be so highly exhausted that convection would be nil, then the relative amounts of heat given off by convection and radiation could be determined without the difficulties attending thermal quantitative measurements. If a source of electric impulses of high frequency and very high potential is employed, a still greater number of the tubes may be taken, and the wires rendered incandescent by a current not capable of warming perceptibly a wire of the same size immersed in air at ordinary pressure, and conveying the energy to all of them.

I may here describe a result which is still more interesting, and to which I have been led by the observation of these phenomena. I noted that small differences in the density of the air produced a considerable difference in the degree of incandescence of the wires, and I thought that, since in a tube through which a luminous discharge is passed the gas is generally not of uniform density, a very thin wire contained in the tube might be rendered incandescent at certain places of smaller density of the gas, while it would remain dark at the places of greater density, where the convection would be greater and the bombardment less intense. Accordingly a tube, t, was prepared, as illustrated in Fig. 23, which contained through the middle a very fine platinum wire, w. The tube was exhausted to a moderate degree, and it was found that when it was attached to the terminal of a high frequency coil the platinum wire, w, would, indeed, become incandescent in patches, as illustrated in Fig. 23. Later, a number of these tubes with one or more wires were prepared each showing this result. The effect was best noted when the striated discharge occurred in the tube, but was also produced when the striæ were not visible, showing that even then the gas in the tube was not of uniform density. The position of the striæ was generally such that the rarefactions corresponded to the places of incandescence or greater

FIG. 23.—Curious Incandescence of a Wire.

Utilising the Heating Effect of Conduction Current and Bombardment.

brightness on the wire, w. But in a few instances it was noted that the bright spots on the wire were covered by the dense parts of the striated discharge, as indicated by l in Fig. 23, though the effect was barely perceptible. This was explained in a plausible way by assuming that the convection was not widely different in the dense and rarefied places of the striated discharge. It is, in fact, often observed in bulbs that, under certain conditions, a thin wire is brought to higher incandescence when the air is not too highly rarefied. This is the case when the potential of the coil is not high enough for the vacuum, but the result may be attributed to many different causes. In all cases this curious phenomenon of incandescence disappears when the tube, or rather the wire, acquires throughout a uniform temperature.

Disregarding now the modifying effect of convection, there are then two distinct causes which determine the incandescence of a wire or filament with varying currents—that is, conduction current and bombardment. With steady currents we have to deal only with the former of these two causes, and the heating effect is a minimum, since the resistance is least to steady flow. When the current is a varying one, the resistance is greater, and hence the heating effect is increased. Thus, if the rate of change of the current is very great, the resistance may increase to such an extent that the filament is brought to incandescence with inappreciable currents, and we are able to take a short and thick block of carbon or other material and bring it to bright incandescence with a current incomparably smaller than that required to bring to the same degree of incandescence an ordinary thin lamp filament with a steady or low frequency current. This result is important, and illustrates how rapidly our views on these subjects are changing, and how quickly our field of knowledge is extending. In the art of incandescent lighting, to view this result in one aspect only, it has been commonly considered as an essential requirement for practical success that the lamp filament should be thin and of high resistance. But now we know that the resistance of the steady flow of the filament does not mean anything; the filament might as well be short and thick, for if it be immersed in rarefied gas it will become incandescent by the passage of a small current. It all depends on the frequency and potential of the currents. We may conclude from this that it would be of advantage, so far as the lamp is considered, to employ high frequencies for lighting, as they allow the use of short and thick filaments and smaller currents.

If a wire or filament be immersed in a homogeneous medium, all the heating is due to true conduction current, but if it be enclosed in an exhausted vessel the conditions are entirely different. Here the gas begins to act and the heating effect of the conduction current, as is shown in many experiments, may be very small compared with that of the bombardment. This is especially the case if the circuit is not closed, and the potentials, of course, very high. Suppose a fine filament enclosed in an exhausted vessel be connected with one of its ends to the terminal of a high tension coil and with its other end to a large insulated plate. Though the circuit is not closed, the filament, as I have before shown, is brought to incandescence. If the frequency and potential be comparatively low, the filament is heated by the current passing through it. If the frequency and potential, and principally the latter, be increased, the insulated plate need be but very small, or may be done away with entirely; still, the filament will become incandescent, practically all the heating being then due to the bombardment. A practical way of combining both the effects of conduction current and bombardment is illustrated in Fig. 24, in which an ordinary lamp is shown provided with a very thin filament, which has one of the ends of the latter connected to a shade serving the purpose of the insulated plate, and the other end to the terminal of a high-tension source. It should not be thought that only rarefied gas is an important

Illustrating Lateral Diffusion.

Incandescence of a Solid

factor in the heating of a conductor by varying currents, but gas at ordinary pressure may become important if the potential difference and frequency of the currents is excessive. On this subject I have already stated that when a conductor is fused by a stroke of lightning, the current through it may be exceedingly small, not even sufficient to heat the conductor perceptibly, were the latter immersed in a homogeneous medium.

From the preceding it is clear that when a conductor of high resistance is connected to the terminals of a source of high-frequency currents of high potential there may occur considerable dissipation of energy, principally on the ends of the conductor, in consequence of the action of the gas surrounding the conductor. Owing to this, the current through a section of the conductor at a point midway between its ends may be much smaller than through a section near the ends. Furthermore, the current passes principally through the outer portions of the conductor, but this effect is to be distinguished from the skin effect as ordinarily interpreted, for the latter would or should occur also in a continuous incompressible medium. If a great many incandescent lamps are connected in series to a source of such currents the lamps at the ends may burn brightly, whereas those in the middle may remain entirely dark. This is due principally to bombardment, as before stated. But even if the currents be steady, provided the difference of potential be very great, the lamps at the ends will burn more brightly than those in the middle. In such case there is no rhythmical bombardment and the result is produced entirely by leakage. This leakage or dissipation into space when the tension is high is considerable when incandescent lamps are used, and still more considerable with arcs, for the latter act like flames. Generally, of course, the dissipation is much smaller with steady than with varying currents.

I have contrived an experiment which illustrates in an interest-

tea, provided by Messrs. Johnson Bros., New-street, was then partaken of in the committee room, the engines meanwhile running slowly. After tea the electricians switched the alternators on to the omnibus bars at the station, and shortly before a quarter past seven o'clock Councillor Garton, chairman of the committee, and Councillor Marshall, vice-chairman, having taken up positions by the circuit boards, respectively switched on the No. 1 and No. 2 circuits amid applause, the lights in the town being immediately started. Five minutes afterwards a telephone message was received to the effect that the lights in the Town Hall, the Market Hall and the main streets were burning steadily. The station itself is lighted by means of arc and incandescent lamps. The wiring is by Mr. Alfred Sykes, of Turnbridge, Huddersfield.

Mr A. B. Mountain gave an account of the Corporation's undertaking for supplying electric light, in which he stated most of the facts given above. In concluding he observed that it would, of course, be understood that in the interests of the undertaking it was very desirable to have as many consumers as possible connected with the mains, so that the machinery, when running, would be supplying some considerable quantity of light. The mains had been so laid in the centre of the town that any consumers could be reached by very slight extension of the mains, and it was hoped now that the light could be seen and its good qualities admired, those who had been hesitating would send in their applications immediately.

Councillor Garton presided in the committee room at a convivial ceremonial after the inauguration, and thanked those present for their attendance. **Councillor Marshall** also spoke, as did **Alderman Glendinning** and **Alderman Haigh**, while the **Mayor** proposed the "Contractors," to which toast **Mr Mordey** responded, observing that as far as the Brush Electrical Engineering Company was concerned, it was in a very satisfactory state. It was not the first opportunity he had had of meeting members of that committee. Nearly two years ago he was at Bournemouth, when the committee, who were going throughout the country, came there, and he remembered that so many questions were put to him that he was nearly exhausted with answering them. He had been asked to speak a few words with regard to the commercial prospects of electric lighting. The subject was such a wide one that he could take a whole evening in dealing with it. He proposed to speak not on the engineering, but on the general prospects of electric lighting especially in a case like theirs. He believed they had that day inaugurated what was bound to be a successful commercial undertaking, as well as a successful engineering one. Alderman Haigh had alluded to the fact that at certain places the committee called they were not able to get a direct answer in the affirmative as to whether the works paid a dividend or not. He was afraid that was true, but it must be remembered that in many cases the people to whom the question was put were the pioneers. In Huddersfield they had the advantage of benefiting by others' experience. The plant they had put down and adopted had been fully tried; everything that was weak or wrong had been eliminated, and they had the kind of plant that would give the most efficient results in every way, and give the least trouble to the people who had to work it. He thought that the success of the undertaking would not be delayed very long. As to the cost of working he understood they had arranged to charge 6d. per unit. There was a great deal of confusion some times as to what a unit was. He believed that in Huddersfield gas was 3s. a 1,000. If that was so, then they would get as much electric light for 3s. as they got gas light; that was to say, electricity at 6d. a unit was equivalent in light-giving power to gas at 3s. a 1,000. They saw, therefore, that instead of electric light being a dear light, it was practically the same price as they were paying for their gas. Of course there were many advantages connected with electricity, such as coolness and healthfulness, and the decorations of houses were not affected at all, as they were by gas. He believed the adoption of the electric light would lower the death rate. Then people were finding that they could use underground premises by adapting electric light which would otherwise be useless. He was not an opponent of gas, on the contrary, he was a believer in it, not, however, for lighting, but for heating and cooking and power. He thought there ought not to be 10,000 little places, each sending out its little column of smoke, but that all coal should be collected in one place and the fuel supplied in the form of gas. The gas engine, he believed, was the engine of the future. Nothing even now could compete with gas for a small engine. For running factories and for regular work from six in the morning to six or seven at night, he did not think it would ever pay to supply power by electricity, simply because a horse-power cost 6d., a unit being equal to about 1 h.p. At Newcastle, where Mr. Mountain had been schooled—and in Mr. Mountain they had a gentleman who had had a great deal of experience—electricity was supplied at a lower rate than any other station in the country or the world. With plant which he (the speaker) designed they were producing energy at the rate of 2½d. per unit, and were selling it at 4½d., actually bringing the sale price with discount down to 4d. At this price it was paying, and paying well. He believed that Mr. Mountain would do better in Huddersfield, because for one thing he had better engines. Then they had water for condensing, and cheaper coal, and as they had customers he thought there was no doubt whatever that the undertaking would be a sound commercial one from the very commencement. The plant was arranged in such a way that they could always work it most economically. He could congratulate the committee on the result of its labours as to the choice of a system, although his company manufactured a large quantity of low tension plant as well as high. Engineers were all coming round to the view that to get over long distances they must have high tension. In Huddersfield they were able to run to Edgerton, about two miles, whereas in Bradford they were absolutely limited by the low tension to a few hundred yards. In conclusion, he had to thank his colleagues, Mr. Mahood for carrying out the work of erecting the machinery, and also Mr. Geipel who was responsible for the engineering of such plant, and Mr. Raworth, the chief engineer of the company. As neither of the latter two could be present, he had come that evening on their behalf.

Alderman Brigg proposed the health of their chief engineer, Mr. Mountain. He referred to the fact that Mr. Mountain was a young man, and remarked that the ability he had displayed in carrying out the work so far must have surprised everyone.

Mr Mountain thanked the company for the way in which they had drunk his health. The work had been a very great pleasure, and he had every confidence that the undertaking would be a success.

COMPANIES' MEETINGS.

EDISON AND SWAN UNITED ELECTRIC LIGHTING COMPANY, LIMITED.

The tenth annual meeting of the shareholders took place on Friday last at the City Terminus Hotel, E.C., under the presidency of Mr. J. Staats Forbes (chairman). The secretary (Mr. H. C. Gover) read the notice calling the meeting, and the report was taken as read.

The **Chairman**, in moving the adoption of the report, said: I think the essential part of the report is in a nutshell, and it is embraced in this—that the gross receipts of the year are the largest the Company has ever obtained, the expenses are exactly in the same description, for reasons which I will presently more explain, and the net profit for the year has been increased by £11,832. The position of the Company is, as you know, approaching a moment when there will be a considerable change—the period of protection will expire in November, and we should have been very much failing in our duty to you if we had not anticipated that period for some years. We have been working on a well-considered design for a number of years, the design being that when we emerge from protection we shall be prepared for competition. I daresay we shall have some. This is the tenth complete year of our existence, and it is worth while calling your attention to the fact that in the first five years we paid no dividend at all, and we began the sixth year with an enormous incubus in the shape of the cumulative claim of the "A" shareholders—£121,000 in round figures. During the five succeeding years electric lighting extended somewhat rapidly in comparison with the earlier years, and we have been able not only to pay the 7 per cent. preferential dividend secured to the "A" shareholders, but to wipe off that considerable amount of £121,000; so that, in fact, we emerge from the protected period, having paid 7 per cent. for the whole of the 10 years, and as regards this present year, with the addition of 3 per cent. out of the profits. The balance of profit, you will see on turning to the profit and loss account, amounts to £86,642, and you will also see how we propose to appropriate it. When we began the year, the balance of arrears on the cumulative "A" shares amounted to £8,261—that was the last remnant of the £121,000 which we began with five years ago. That, of course, had to be got rid of, and it was done by an interim payment at the end of the first six months, in addition to which we paid 3½ per cent. for the half year ended December 31—£12,371—on the "A" shares. Now we propose to make up the 7 per cent. preference dividend which the "A" shares are entitled to and, for the first time in our history, the position of the "B" shares is to be taken into account in regard to dividend. This £117,000 worth of shares represents the interest of Mr. Edison and his friends as the purchase price of the patents and the founding expenses of the Edison Company, and is held subject to this—that they participate to the extent of one-fourth in any profit of the undertaking after we have satisfied the 7 per cent. preference claims of the "A" shares. I hope the participation of the "B" shares in our profits will endure. We carry over the very considerable sum of £39,148; but seeing what is before us, we think we should have a strong reserve, and the Directors have had no hesitation in what they conceive to be their duty to you in recommending a 10 per cent. dividend, instead of one which of course, was possible if we had trenched further on the profit of the year. What we have to consider is whether the profit of the year, as represented in these figures is likely to be maintained in face of the competition which, at all events, may be tolerably severe. We shall not escape the inevitable, and must endeavour to hold our own. We think that with our good organisation, a large connection, strong reserve, and a good name we shall be able, if not to see such large results as during the protected time, at all events to retain sufficient business to make the dividend a very fair and reasonable one. What it will be no man can tell; but what I do know is that we shall have to keep our eyes open and put our best foot forward in the next two or three years. With that view we have become manufacturers as well as lamp makers. For a very long time we were so bitten by the errors of the two companies—the Edison and the Swan—in entering upon installation business and contracting for supplies of light and so forth, that we determined not to touch that work until we saw our way very clearly; therefore, for a number of years we pursued the humble rôle of lamp makers. Latterly we have merged into the business of manufacturers of appliances for fitting and installation in houses and elsewhere, and although the lamp patents expire in November, we have other

valuable patents in connection with the appliances which are already bringing in a considerable annual income, and which extend over a tolerably long term of years. In respect of these patents, for holders and so forth, we have continued to manufacture them for ourselves, and charged ourselves the same royalty as we charge our licensees and we have licensed a large number of leading firms in the gasfitting, lampfitting, and brassfounding business who are competing with us in the sense that they are bound to sell at the same price as we do, and are paying us a royalty. Of course, this business is of the character of many others; the fixed charges are considerable, and are not influenced by the number of lamps sold. The price of the lamp is ear marked, and you can produce a large number at a rate per lamp considerably less than a smaller number, and we have attained that position in which we can produce lamps as cheaply, certainly as anyone in this country, probably in Europe. The reputation of the lamp seems to be established. I daresay when the competition comes on us we shall have lamps from all parts, Germany and the Continent generally. We know pretty well what those lamps are, and have a knowledge which enables us to measure possibilities, and although, no doubt, the number of lamps sold may in the first moment of this competition be affected, more or less, we must look to the general development of the business, and to our being able to hold our own in the total output of lamps, which must, year by year, greatly increase, because only quite recently the electric light business seems to have improved. One has the opportunity of reading in the papers the speeches of gentlemen connected with electric lighting companies, and we have been interested to learn in that way how the Westminster, the St. James's, the Metropolitan and other companies have all largely increased the number of their lights. All this means the rapid multiplication of lamps. When the time comes we must endeavour to hold our own relatively to the general advance in this business, which I believe I can foresee will be considerable during the next few years. There is another thing to which I should like to call your attention. The gross income, including the stock, you will see is £240,271, as against £212,048 last year, an increase of £28,223. The gross expenses have been £153,629, compared with £137,236, or more by £16,393, leaving a net profit of £11,831 in addition to that of last year. That £16,000 is rather a large increase in the expenditure, but this year, for the first time, we have had to bear the burden of the establishment of a number of depots. As our business extends, people who live in the great centres of industry will probably get tired of drawing their supplies from the factory at Ponder's End, therefore we were determined to try the experiment of a London depot, and we opened one in Parliament street, Westminster, where we have done an extremely good business. We have also opened another at 110, Cannon street, with like satisfactory results. In addition to the two depots in London, we have opened one each at Birmingham, Cardiff, Liverpool, Leeds, Newcastle, Hull, Dundee, Glasgow, Belfast, and Dublin, and we are doing business in all those places. Now, I should like to say a few words with reference to our solid asset, and by that I mean our tangible property. The preferred or "A" capital of the company is £353,478, which has a cumulative claim of 7 per cent. before the "B" capital gets anything. It takes £24,743 to pay that 7 per cent. Our capital is £353,478 of subscribed money and £117,820 in deferred shares, in virtue of the benefits accruing from our patents. As, however, these patents are on the point of expiring, not much value can be attached to them for the future; but, as far as the holders of that £117,820 go, they are entitled to a quarter of anything over 7 per cent. on the "A" shares. I hope they will get their quarter, and I think there is a probability that they will get something. But we are more concerned for the people who found the £353,478. Now of that amount we have got a solid asset in the nature of freehold property, plant and stock, debtors, and consols to the extent of £200,000. Of course, that is the value as a going concern; but we have written off these items considerable sums from year to year. We have, then £200,000 and the question now is whether our experience, our capacity to supply the demand, and our trade mark, is worth the balance. You are as capable of judging that as I am. I am sanguine enough to believe it is, and I think we need be under little apprehension that our venture will continue to be certainly a reasonably profitable one, and probably a very profitable one, because, with the extension in the number of lamps sold, we shall speedily retrieve the loss which may ensue upon the sale price of them, when we emerge from the protected period. I do not know whether anyone will be curious upon the subject of accounts; if so, I shall be happy to enlarge upon them. But I think they speak for themselves. I now move the adoption of the report.

Major S. Flood Page (deputy-chairman) seconded the motion, which was adopted.

The **Chairman** next moved: "That a dividend be and is hereby declared on the A shares of the Company of 4s. 0½d. per share on the 89,261 ordinary, £3 paid; of 6s. 8¾d. per share on the 5,000 £5 fully paid shares allotted to the Edison Electric Light Company, Limited; of 5s. 0½d. per share on the 12,139 £5 fully paid shares allotted to the Swan United Electric Light Company, Limited; and of 3s. 2d. per share on the B shares of the Company, being, with the interim dividend paid on March 14, 1893, a payment on the A shares of the Company of the balance of arrears of cumulative preferential dividend, and of 10 per cent. in respect of the year ending June 30, 1893; and on the B shares of the Company 3 per cent. in respect of the year ending June 30, 1893. All to be distributed in accordance with the provisions of clause 87 of the articles of association, income tax free."

This was seconded by **Major Flood Page**, and was unanimously carried.

Mr. Killingworth Hedges referred to negotiations proceeding for an amalgamation of the Swan United Company with this Company, and he should like to hear if there were any chance of the interest of the two companies being brought together. He should like to know whether such an amalgamation would lead to economies being effected.

The **Chairman** said the Board had felt the importance of that amalgamation from year to year, and it had become accentuated as the period of the expiration of the patents approached; therefore, they had given their attention to the subject during the year. A proposition had been formulated, and, substantially, he understood — for, being chairman of both companies, he had stood out of the negotiations — agreed upon, upon which the Edison and Swan would take over the remnant of the business of the Swan Company. There were one or two internal matters which would, however, have to be submitted to the shareholders of both companies before the amalgamation could be carried out. One of the objects of the fusion would certainly be to promote economy of administration.

On the motion of the **Chairman**, seconded by **Mr. Hedges**, Major Flood Page was unanimously re-elected to his seat on the Board, and Mr. Shelford Bidwell, F.R.S., was similarly reappointed, on the motion of the **Chairman**, seconded by **Mr. Cuthbert Quilter, M.P.**

Messrs. Welton, Jones, and Co. were reappointed the auditors, and the proceedings were then brought to a close.

CITY AND SOUTH LONDON RAILWAY COMPANY, LIMITED.

The eighteenth ordinary general meeting was held on Tuesday at Winchester House, E.C., Mr. C. G. Mott (chairman) presiding.

The Secretary (Mr. W. F. Knight) read the notice convening the meeting, and the report was taken as read.

The **Chairman** said it became his duty to move the adoption of the report and accounts. In doing so, he stated that they would be pleased to see that the steady increase in the Company's receipts had continued during the past half year, in spite of the lengthy spell of hot weather which was generally detrimental to the traffic of the line. On the other hand, there had been no increase in the expenditure, but, on the contrary, a small decrease, which was a very satisfactory condition for any company to be in. The Board had again to report that the line had been worked with the greatest regularity, and without any stoppage or detriment whatever. The line itself, he thought, was growing in popularity with the public, who found that it had an almost unexampled regularity of service, perfect punctuality, and a pure atmosphere, free from all noxious vapours, that there was an even temperature, which was pleasant both in summer and winter, and that altogether the line was such as was very much wanted in the metropolis, and was a very great improvement upon all other existing railway communication. Referring to the accounts, the Chairman said they had raised during the half year £17,050 on capital account, this having been used in paying off liabilities amounting to £10,209, and in expenditure on the Stockwell sidings, and various other matters, to the extent of £6,181. They had paid off in the same period £3,800 of the terminal debentures, and had replaced them with 4 per cent. debenture stock, issued at a premium, so that a small saving had been effected in that respect. The amount of debentures falling due that half year was exceptionally small, but in the future the amount would be larger, and they would thus derive an increased benefit and more saving each half year, until they got the whole of those debentures paid off and converted. The receipts from passengers had increased by £1,491, and those from season tickets by £86; in fact, in every department of the receipts there had been an increase, making the total advance for the half year £1,639. The expenses for maintenance had increased by £13, locomotive expenses had decreased by £159, carriage repairs as might be expected had increased by £57, and the traffic expenses showed a decrease of £124. The general charges had increased by £160, this being chiefly due to their having insured against accidents. Although their liability for accidents was exceedingly small, the Board thought it desirable that in the early stages of the railway they should run no risk which might interfere with the dividends. They insured for a considerable amount by paying £200 a year, and he hoped the accident company would reap the benefit, and that this Company might never have to make a claim upon them. He thought the shareholders would agree that this was a wise and prudent course to adopt. Then they had had to pay £24 for passenger duty, which had not appeared in previous half years. The matter had been under discussion with the Inland Revenue authorities for several years, because owing to the fact that they did not issue tickets and that they gave their passengers the right to travel over the whole length of the line, the Company's contention was that they had no means of knowing how far the passengers travelled, and that, that being the case, they were not liable to duty, because the charge came to less than 1d. per mile. The authorities, on the other hand, contended that a certain number of passengers did not travel a sufficient distance to make the rate 1d. per mile. As it was impossible to obtain precise information on the point, a compromise was agreed upon, and the Company consented to pay passenger duty to the extent of £24 as what was due for the past year and one or two previous half years. Law charges had decreased by £32, rates and taxes had increased by £44, and compensation had decreased by £117, the result being a decrease of £134 in the expenditure, making, with the larger receipts, a net increase in the revenue of £1,773. As to the rates and taxes the increase had been going on steadily, and he thought they must look forward to

its continuance. Concerning the percentage of working expenses, in their first half year their expenses were 79 per cent. of the receipts; in the second, 76 per cent.; in the third, 70 per cent; in the fourth, 67·9 per cent.; and last half year, 64·6 per cent. It would thus be seen that there had been a steady, regular decrease in the percentage, and he hoped that would continue until the expenses were cut down to a much lower rate than at the present time. This calculation included the item of lifts, which was an expense not connected with other railway companies. Deducting the cost of working those lifts, their percentage would be 56½, which was very nearly the same as that of many of the larger railway companies. The changes which had taken place in the receipts per train mile were interesting. In the first year the figure was 2s. 1d; in the second, 2s. 1½d; in the third, 2s. 2½d; in the fourth they increased the mileage to a large extent, and the receipts consequently fell to 2s. 0½d per train mile. Last half year, as compared with the December half, they had only made a very small addition to the mileage, and the result had been that they were overtaking the large addition of train mileage, and that the receipts per train mile had risen to 2s. 1½d. The expenses per train mile had been, in the first half year, 1s 9½d; in the second, 1s. 7½d; third, 1s. 7¼d.; fourth, 1s. 5½d; last half year, 1s. 4½d. This was a very satisfactory feature. The locomotive expenses per train mile had been: First half year, 9d.; second, 7·9d; third 7·7d; fourth, 7·1d.; last half year, 6·18d. If they compared those figures with the locomotive expenses of the large railways of England, they must deduct the carriage of the coal, which this Company paid, and which the others did not. Making that deduction, the locomotive expenses per train mile would be reduced to 5½d. for the past half year, which was very little more than half the rate which it cost the large railway companies for steam purposes. The receipts per passenger had been: In the first half year, 1·90d; second, 1·70d.; third, 1·73d.; fourth, 1·60d; and last half year, 1·66d. Those variations were mostly in consequence of the increase or decrease of the local short passenger traffic. A year ago they tried in various ways to get for a mid day traffic a number of short distance passengers at low fares, and they were successful in so doing, but the result was that although they had a general increase in the receipts, it diminished the receipts per passenger from 1·70d. to 1·60d. Last half-year they had a general increase in the longer distance traffic, and the figure had risen to 1·66d, or very nearly the same as before they made the reduction. The new sidings at Stockwell were practically completed, and would be very shortly brought into use. The Directors were anxious to have them in use before the winter traffic commenced. He thought they would enable the company to improve the service during the winter. By putting in an additional signal station between Stockwell and the Oval they had been able to improve the service somewhat during the past half year. The Company's Bill for the extension to Islington had passed the House of Lords. It had to go down to the Commons for consent to certain alterations, and would then only await the Royal assent. The Board were anxious to improve the King William-street Station at the surface, which was dark and confined at present, and was rendered difficult to improve owing to the small space available. They had an opportunity of acquiring the lease of the adjoining property at a very moderate price, and they had obtained that lease, so that they were now considering what alterations they could make at a small expenditure in the way of improving the access at the top of that station. He then moved the adoption of the report and accounts.

Mr. C. Seymour Grenfell seconded the resolution, which, on being put, was carried without any discussion.

The **Chairman** then moved, and **Mr. Sampson Hanbury** seconded, that a dividend at the rate of 5 per cent. per annum on the preference shares be declared. This was adopted, and a dividend at the rate of ¾ per cent. per annum on the consolidated ordinary stock was also declared.

A hearty vote of thanks was passed to the Chairman and other Directors, and the former, in reply, expressed his complete confidence in the future of the undertaking.

CROMPTON AND CO., LIMITED

The fifth annual general meeting took place at the Cannon street Hotel on Monday, under the presidency of Viscount Emlyn, chairman.

The secretary, Mr. F. R. Reeves, read the notice convening the meeting, and the report was taken as read.

The **Chairman** before putting the first resolution, said that although the Directors met the shareholders with a diminished dividend, he was justified in congratulating them on the progress and position of the Company. The turnover of business showed a satisfactory increase over that of the previous year, and the gross receipts on trading exhibited an increase of nearly £3,800. That progress has been made in spite of the severe commercial depression which had, more or less, affected all classes of business, and consequently checked the receipt of orders for their goods. Australia had formerly been a large customer to them, but during the year very little had been done with that country. There were, however, signs that that trade was likely to improve. The orders booked in the last three months had very nearly equalled those in the whole of the previous year, and the outlook from South Africa was promising. The cost of manufacturing goods at the Chelmsford works had again been considerably reduced, and as far as economy was concerned, the Directors had every reason to be satisfied with the progress made in this direction. Unfortunately some exceptional and unforeseen expenses had had to be borne, the principal of which were those attending the temporary arrangements consequent upon the breakdown of the boilers at the works. The water supply there was both expensive and unsatisfactory in quality, and the boilers, when the heavy pressure of the town lighting came on last winter, gave out, and before new ones could be obtained, temporary boilers had to be hired and put into position at great expense. Since then, however, new boilers and pumping plant had been provided, and substantial savings were now being made in that department. Another item of expense beyond the normal had been the cost of advertising. That was being closely watched, so as to effect considerable reductions during the current year. The extraordinary general meeting last October had sanctioned the nominal increase of the capital to £300,000. The cost of registering this capital, and the expense of issuing the prospectus and advertising, had been temporarily charged to a suspense account, and would be written off in equal instalments in about three years. Since the last meeting, 2,781 preference shares and 1,928 ordinary shares had been placed. The list of applications for debentures had also been closed, and the committee of the Stock Exchange had granted a quotation for these securities. The stock in trade showed a considerable increase over previous years. A satisfactory feature of the increase, consisting as it did mainly of finished parts of machines, was that it enabled the Company to make quick delivery, and that fact often secured them an order. The item "trade debtors" showed an apparent decrease, but that was due to the transfer of the Chelmsford lighting account to the heading of "Investments." With regard to the profit and loss account, the net profits were some £3,000 less than last year, and the Directors did not therefore recommend a full dividend on the preference shares. They felt sure that the shareholders would agree with them that that was the proper course to adopt. The dividend on the preference shares was cumulative, so that the balance of 1 per cent. unpaid was carried forward to next year as a first charge after debenture interest on the future profits of the Company. The works at Chelmsford and Lillie Bridge were in first-rate order and well equipped; the Company had a good staff of engineers and officials, and was served by an excellent body of workmen. It would be gratifying to learn that the Crompton arc lamp had been so improved that it now held the position of being the best and cheapest in the market, and considerable orders had been received for it. He then moved the adoption of the report and accounts.

Mr. R. E. Bell Crompton, in seconding the motion, said that they had not made as good a year as they ought to have done. General bad trade had had a great deal to do with it, and individual bad luck in the case of the exceptionally large sums spent on the power department for the boilers at Chelmsford had been the causes which had led to the diminished profits; but he could corroborate the Chairman that there was nothing to lead them to believe that this state of things should point towards diminished profits in future. He thought everybody would admit that the period now being passed through was a period of depression in all trades, and that it had reached a point at which they must at least hope for a turning, and he did not think they would be found unfitted to take advantage of a revival. It had been the aim of the managing Directors to look for every possible means of providing steady work for the Chelmsford shops that would be in the nature of a backbone to the business. The manufacture and sale of dynamos had always been part of such a backbone, and although Crompton and Co. for many years past had been well known as makers of arc lamps, yet for the past six or seven years it had been quite an insignificant item. They had now developed this arc lamp so as to cause it to be asked for on all sides, and that made him very hopeful that they would discover a second string to their bow in the shape of a steady manufacture which they could always go on making for stock at all times, knowing perfectly that there was certain to be a demand whenever the normal state of affairs came again. He thought during the ensuing year, from what he had seen of the demand for the new lamp, that it promised well to yield something substantial towards next year's profits. With regard to the heavy cost of the boilers he could not say very much. It was more in the nature of a pure accident that the boilers gave out as they did. They well knew that the demand in consequence of the lighting of Chelmsford being added to the ordinary demands of their works, would be very considerable during last winter, but they did not reckon upon the extreme badness of the water supply damaging the boilers before the new boilers could be got into position. The hurried work and the hired work which had to fill up between the failure of the old boilers and the getting in of the new permanent boilers was a very costly operation. He thought, however, they had taken steps to prevent the possibility of anything of the kind recurring. Of course accidents might happen, but they had taken all possible and reasonable means to prevent them. They had adopted the type of boiler that was best suited for very bad water, and in addition to that they had put down water purifying plant, and had taken advantage of the change of boilers, which would enable them to burn very cheap coal. Thus the troubles in the past might be a source of profit to them in the future. He believed the cost of producing power at Chelmsford would be very much lower than it could have been with the old type of boiler. There had already been a steady decrease in the expenses under this head. He need hardly say that the hard state of affairs affected the managing Directors more than anyone else in the Company, and they had therefore a very strong incentive to see it put right as quickly as possible. No one could regret more than himself that they had not got their full dividend. He then seconded the motion.

The **Chairman**, in reply to Colonel Wood as to the depreciation fund, said he believed that their plant was put down in the depre-

ciation account to its full amount, and that it had this year been increased by £500. The amount was sufficient to cover all ordinary expenses and wear and tear, but he did not know that it could cover every accident In answer to Mr. Kitchin, he remarked that the Chelmsford lighting was getting in a satisfactory state, and in a short time they hoped it would be paying its way on fairly commercial lines With regard to the cost of the breaking down of the boilers, they had had to expend a considerable amount (£2,000) on temporary work alone to enable them to carry on the lighting. As to the increase of stock, that cut both ways. They had been trying some time to meet orders when wanted in a hurry, and very often an order could be secured and carried out with a given stock, whereas with a low stock they lost the business. Whether they had reached the happy medium of having too much or too little he could not say, but they had stock that would enable them to deal with orders which otherwise they might lose. With regard to investments in shares of other companies, their object was not to do anything of that kind, but they were sometimes obliged to have an interest in some companies in order to get orders.

The resolution was then put to the meeting, and was unanimously adopted.

On the motion of the **Chairman**, seconded by **Mr. J F Albright**, a dividend of 2s 6d. per share, making with the interim dividend 6 per cent. per annum on the preference shares, was declared.

Mr. H. H J. W. Drummond was re-elected a director, and Messrs. J. H. Duncan and Co were reappointed auditors. A vote of thanks to the Board terminated the proceedings.

DIRECT UNITED STATES CABLE COMPANY.

The thirty-second ordinary general meeting of the Direct United States Cable Company, Limited was held on the 29th ult. at Winchester House, under the presidency of Sir John Pender

The **Chairman**, in moving the adoption of the report, said the revenue for the half year ended June 30 last, after deducting out-payments, amounted to £40,836, and the working and other expenses to £18,898, leaving a balance of £21,938 as the net profit of the half year. This with £3,129 brought forward from the previous half year, made a total of £25,067. Three quarterly interim dividends of 3s. 6d each per share amounting to £31,872. 15s. had been declared and paid during the financial year, and a final payment of 3s 6d. per share was now proposed, making, with the three interim dividends, 3½ per cent for the year, being a total distribution of £42,497 After transferring £3,000 to the reserve fund account, which now stood at £267,415. 12s. 7d, the balance of £819. 2s 4d. on the revenue account was proposed to be carried forward. The revenue, as compared with that of the corresponding period of the previous year, showed an increase of £1,822. Considering the general depression which had prevailed, this result must be regarded as satisfactory.

The report and accounts were adopted.

ANGLO-AMERICAN TELEGRAPH COMPANY.

The half yearly general meeting of the Anglo American Telegraph Company, Limited, took place on the 29th ult., at Winchester House.

The **Marquis of Tweeddale**, in moving the adoption of the report, said that the receipts had amounted to £146,886, an increase of £367, and the best the Company had experienced for some time The beginning of this month was unsatisfactory, but the latter part of it had placed the receipts a little above what they were last year. The working expenses showed an increase of £818, mainly due to the loss caused by fire at St. Johns, and to the increase in salaries. The net result had been an interim dividend of 12s. 6d on the ordinary stock not a very large return, but it was paid on a stock which had been heavily watered to the extent of about 50 per cent. The proprietors had no doubt noticed with a certain amount of satisfaction that the reserve fund now stood at £1,007,261, or £7,000 above the million of which they had often talked. Whether this sum could be made available for dividend purposes must depend on the freedom from further interruption, and on the speed and economy with which the present interruptions were being repaired.

The report was adopted.

ELECTRICAL POWER STORAGE COMPANY.

The fourth ordinary meeting of this Company was held at the offices of the Company, 4, Great Winchester-street, E C., on July 27, Mr. J. Irving Courtenay, the chairman of the Company, presiding.

We have been favoured with the following report of this meeting by the secretary of the Company

The Secretary (Mr. J W Barnard) having read the notice convening the meeting, the **Chairman** said In making some observations upon the accounts, I desire to point out that the difference in the balance carried forward from the trading account this year and last year is mainly owing to proper deductions having been made in balancing the trading account, the discounts and other charges having been deducted before bringing forward the balance. The gross amount of orders is larger than last year, but owing to the reduction in price, and increased discounts to the trade, the net cash received is rather less. But you will also notice that in consequence of economies having been introduced into the management and into the manufacture, the net profits are practically the same, because from the amount of the profits we have written off this year £1,500 towards depreciation of patents. The Company is selling more of its manufactures than it did, and thus it is increasing its goodwill and obtaining a larger business with the public, because the objections taken in past years to the high price of accumulators have been to a considerable extent a removed by the reductions in question Now you are all aware of the depressed condition of trade, and that the electrical industry, like all other businesses, is suffering from the depressed times, but I am glad to say that the E P S Company has done well in spite of this almost unprecedented depression We do business with all the leading firms, and the result is that whatever business is going we get a share of. We have competition to contend against, and no doubt shall always have, but I think by the improvements that have actually been made, and those we have in contemplation, and by the economies these will effect in the manufacture of the batteries, we shall be able to hold our own. We are, as you are aware, also acquiring patents for details in manufacture, and so in reality, though the basic patents are growing older, we are strengthening the position by these newer patents. One of the most vital questions for the E. P. S. Company is traction. You know that this Company associates itself almost entirely with what is called self-contained traction, and has endeavoured to develop it, though up to the present not with the results we aim at; but we do not for one moment despair of ultimate success A portion of the expenditure in legal charges was incurred in what at one time looked a hopeful business in endeavouring to obtain an Act of Parliament in an important provincial town for an electrical tramway We failed because we could not get the necessary agreements confirmed in time for Parliament, and so the Bill was dropped. But we are persevering (not in that particular locality) with self contained traction, and you have heard of a small company that has been formed -I refer to the Pioneer Electric Carriage Company to develop a form of traction with novel features, among which is the pneumatic wheel Some few of our friends have put their money in to test it, and, if successful, it will be a great benefit to the E P S Company and bring a wide demand for its batteries—such is the interest the E.P S has in the welfare of that concern. I do not think I need trouble you with any further remarks, and conclude by saying so far as is possible to see ahead in these days, I entertain no doubt that the E P S. Company will continue to prosper. I now move: "That the Directors' report and statement of accounts to May 31, 1893, be and are hereby approved and adopted, and that a dividend of 5 per cent on the paid up capital be declared, payable on August 24, 1893."

Sir Daniel Cooper. I beg to second.

Mr. J W Barclay: I do not intend to offer any criticism of the accounts, but to refer to a point which invites attention—viz., the use of accumulators for propelling carriages. Shareholders of the Pioneer Electric Carriage Company are endeavouring, at their own expense, to develop a system of self contained traction for ordinary carriages. If the attempt prove successful, a very wide field for the use of accumulators will be opened up. Meanwhile the problem we have before us is to prove that this new method of locomotion is useful, commodious, and economical. The operations of the Pioneer Company should certainly encourage shareholders to be hopeful for the future of the electric storage battery industry.

The resolution was then carried unanimously, and the retiring director, Sir Daniel Cooper, Bart., G C M G, having been re-elected, other formal business was concluded. In responding to a vote of thanks, the **Chairman** observed: I should like to say I have waited for this opportunity of expressing our indebtedness to Mr. Frank King and staff for the keen and intelligent energy with which they have pushed the business of this Company. The Directors will bear me out when I say that Mr King and his staff spare no effort to promote in all directions the interests of the E.P S Company.

Mr. Frank King On behalf of the staff and myself, I beg to thank the meeting and the chairman. It is our duty to convince engineers and others that the secondary battery, as manufactured by the Company, is the very best battery, for all purposes, they could possibly desire. We have been successful in this, and it is a great satisfaction to us to know that our efforts are appreciated.

The proceedings then terminated.

The following is the report of the Directors and accounts of the Company for the year ended May 31, 1893:

The profit, after payment of general expenses, management, etc., is £5,245 2s. 2d, from which the Directors have, in deference to the wishes of the auditors, deducted a sum of £1,500, writing that amount off the patent account, leaving with a balance of £626 7s 7d. from last year, an amount of £4,371. 9s. 9d available for distribution, out of which the Directors recommend the payment of a dividend of 5 per cent., leaving £158 19s. 5d. to be carried forward. Provision has also been made for maintenance of buildings, plant, tools, etc., by writing off the sum of £2,083 18s. 9d. The Directors are pleased to be able to report the continued success of the Company's operations; a considerable reduction in the selling price of its manufactures has been made, for the purpose of bringing storage batteries into more general use Particular attention has been devoted to securing such inventions as would tend to cheapen production while combining maximum efficiency and durability, and with this object several new patents have been acquired, and sole licenses for others have been obtained. Constant attention has been also given to the development of electric traction, for which the Directors expect a considerable demand will shortly arise. The Company and its licensees have been successful in patent litigation abroad. The retiring Director is Sir Daniel Cooper, Bart., G.C.M.G., who, being eligible, offers

himself for re-election. The auditors, Messrs. Broads, Paterson, and Co., retire as usual.

BALANCE-SHEET, MAY 31, 1893.

Dr. Liabilities.	£	s.	d.	£	s.	d.
Capital authorised: 20,200 shares of £5 each, of which 100 are founders' shares				100,500	0	0
Issued 18,723 shares of £5 each, of which 66 are Founders' shares				93,615	0	0
Paid up 15,120 shares, fully paid				75,600	0	0
3,537 shares, £3 paid				10,611	0	0
				86,211	0	0
Less calls in arrear and on forfeited shares				1,369	1	3
				84,841	18	9
Less amount paid on forfeited shares				400	0	0
				84,441	18	9
66 founders' shares fully paid				330	0	0
18,723				84,771	18	9
Sums paid on forfeited shares				400	0	0
Sundry creditors				7,024	14	7
Bills payable				15,192	16	11
Profit and loss account. Balance of account at May 31, 1892, after paying dividend at 6 per cent.	746	7	7			
Less auditors' fees to May 31, 1893	120	0	0			
	626	7	7			
Add, profit for current year	3,745	2	2			
				4,371	9	9
				£111,761	0	0

Cr. Assets.	£	s.	d.	£	s.	d.
Patents, &c., at cost amount at May 31, 1892	75,160	0	0			
Purchased during the current year in exchange for fully paid shares of the Company	600	0	0			
	75,760	0	0			
Less amount written off to profit and loss	1,500	0	0			
				74,260	0	0
New plant, tools, furniture, fixtures, and fittings	1,086	11	2			
Less 10 per cent. depreciation	108	13	2			
				977	18	0
Sock on hand:						
General stock at cost or under	12,527	7	5			
Stationery at cost £229 18s 2d., less 50 per cent. depreciation	114	19	1			
				12,642	6	6
Book debts, less reserve for doubtful debts, etc				16,697	8	1
Bills receivable				1,251	8	7
Investment account				600	0	0
Cash: At bankers	5,292	8	1			
In hand	39	10	9			
				5,331	18	10
				£111,761	0	0

PROFIT AND LOSS ACCOUNT, YEAR ENDED MAY 31, 1893.

Dr.	£	s.	d.
Rent, taxes, licenses, etc	9,845	7	8
Less rebate on payment of dividend at the rate of 5 per cent. per annum on ordinary shares	4,000	0	0
	5,845	7	8
General expenses, management, Directors' fees, etc.	6,266	18	6
Advertising, insurances, and travelling expenses, etc.	2,555	19	9
Commissions, interest, etc.	1,167	15	3
Patent fees and charges and law expenses	1,983	6	5
Patents, etc.—Depreciation written off	1,500	0	0
Maintenance of buildings, plant, and tools	1,860	6	6
Depreciation written off plant, tools, etc	108	13	2
Auditors' fees	120	0	0
Balance, being net profit carried to balance-sheet	3,745	2	2
	£25,453	9	5

Cr.	£	s.	d.
Balance from trading account	25,215	9	3
Rents receivable, etc	238	0	2
	£25,453	9	5

GLOBE TELEGRAPH AND TRUST COMPANY.

The twentieth ordinary general meeting was held on the 27th ult. at Winchester House, under the presidency of Sir John Pender, M.P.

The **Chairman**, in moving the adoption of the report, said the net revenue for the year ended July 18, after the payment of expenses, amounted to £188,931, as against £192,243 last year, or a decrease of £3,312. This decrease, which was but a small one considering the general depression which had existed during the past year, was accounted for by the fact that they had received somewhat reduced dividends from four or five of the companies in which they held investments. On the other hand, there were two or three of the companies which had given them a better return this year than they did in the previous year. This enabled the Directors to recommend the payment of a dividend on the ordinary shares of 4½ per cent. for the year under review. Last year they were able to pay 4¾ per cent., or 6d. more than they proposed to pay this year. The average dividend which the Company had paid since its formation in 1873 was 4¾ per cent., so that the present dividend was above the average, and therefore it was not disappointing.

The **Marquis of Tweeddale** seconded the resolution, which was carried.

CHILI TELEPHONE COMPANY, LIMITED.

The ordinary general meeting was held on Wednesday at Winchester House, Colonel R. Raynsford Jackson (chairman) presiding.

In moving the adoption of the report, which was given in our last issue, the **Chairman** said that the net profits in London for the past year amounted to only £5,395, although the income in dollars from subscribers showed an increase of 69,834dol. The fact was that the fall in exchange was directly responsible for a diminution in their revenue of £7,642. As the tariff rates were paid in the paper dollar, which was now so greatly depreciated, the Board felt that they ought to increase these rates. Already that course had been pursued in some important centres, and they were about to do the same in all of them. Another thing on which they relied was the decision arrived at by the Chilian Government to gradually withdraw the paper money and establish a sound currency. The profit earned during the past year was used for capital purposes, but they had now practically closed that account, at least for the present, as they were only spending the money necessary to couple up new subscribers. He hoped, therefore, that during the current year they might be able to set aside, out of revenue, a sufficient amount with which to pay a dividend.

Mr. T. Greenwood seconded the motion, and the report was adopted.

MANCHESTER EDISON-SWAN COMPANY, LIMITED.

The eleventh ordinary general meeting of this Company was held last week, Mr. V. K. Armitage, chairman of the Company, presiding.

In the annual report which was taken as read, it was stated that the net profit, including last year's balance, amounted to £2,047 14s. 9d. Of this it was proposed to devote £1,000 to the payment of a dividend at the rate of 5 per cent. per annum, and £873 15s. towards the loss incurred in connection with the Williamson Electrical and Engineering Company, Limited, of Australia, carrying forward a balance of £173 19s. 9d.

The **Chairman**, in moving the adoption of the report, referred to the depressed state of electrical business and business in general during the past year, and said the Manchester Edison Swan Company had suffered a good deal through the delay of the Manchester Corporation in carrying out their installation, as people did not care to go forward with installations on their own account till they saw what the Corporation were going to do in the matter. The Corporation seemed now to be within measurable distance of the completion of their works. The net profits of the Company had been about £800 less than in the preceding year. Although the result was to that extent unfavourable, he was not without hope as to the future of the Company. There could be no doubt that there would be a very great spread of electric lighting in the immediate future, and they hoped and believed they would get their share of the work that had to be done. Nearly all the business they had done had been remunerative work, and with increased business they would have an increase in the amount of their profits.

The motion was seconded by **Mr. W. P. James Fawcus**, and after some criticisms on the accounts had been passed, it was put to the meeting and adopted with only one dissentient.

It was agreed that the profits should be disposed of in the manner suggested in the report, except that out of the balance to be carried forward £150 was voted as remuneration to the Directors.

BUSINESS NOTES.

Cuba Submarine Telegraph Company.—The Directors propose a half yearly dividend at the rate of 8 per cent. per annum.

South London Railway.—The City and South London Railway Bill was read on Monday in the House of Lords for the third time.

Burnley.—It was mentioned on Wednesday at a meeting of the Town Council, that the electric light station had now been completed, and that the current would be switched on next week.

Lyons.—The central telephone offices at Lyons took fire on Saturday, and it was found necessary to cut the whole of the 1,250 connecting wires. The damage sustained is estimated at £1,000.

Mill Lighting.—A new spinning mill, recently erected at Eagley for Messrs. J. Chadwick and Brother, Limited, is being lighted electrically by Messrs. Ernest Scott and Mountain, Limited, of Newcastle.

Agents Wanted.—As will be seen from our advertisement columns, Mr. Ronald A. Scott, of Acton Hill, London, W., is desirous of appointing a good agent for Newcastle, Liverpool, and Cardiff, and the adjoining districts.

Bolton.—An inquiry was to be held yesterday by Major-General Crozier, R.E., one of her Majesty's Local Government Inspectors, into an application by the Bolton Corporation for sanction to borrow £40,000 for the purposes of electric lighting.

Hampstead - Charing Cross Railway.—On Monday the Unopposed Bill Committee of the House of Lords passed the Hampstead, St. Pancras, and Charing Cross Electric Railway Bill. This scheme has been sanctioned by the House of Commons.

Electrocution.—A defect in the chair on the carrying out of the execution of Wm. Taylor at Auburn Prison, New York, caused the dynamo to give out, and a second shock could not be given for an hour. The current in the latter case was obtained from the street mains.

City and South London Railway Company.—The receipts for the week ending July 30 were £822, against £735 for the same period last year, or an increase of £87. The total receipts for the second half year of 1893 show an increase of £404 over those for the corresponding period of 1892.

Nottingham.—The Electric Lighting Committee of the Corporation have opened the tenders (11 in number) for the electric light station to be erected in Lower Talbot street. The tender of Mr. F. Messom, of Nottingham, builder and contractor, was accepted, at the price of £10,209.

Lancaster.—Tenders for the erection of engine and boiler house, etc., at the central station for electric lighting in Lancaster, have been let to the following tradesmen of the town: Mason's work, Mr. W. Harrison; joiner's work, Mr. Jonathan Acton; plumbing, Mr. William Abbott; plastering, Messrs. T. Cross and Son.

Exhibition at Nottingham.—An industrial exhibition, organised in honour of the forthcoming visit of the British Association, was opened in the Victoria Hall on Wednesday. The electric light of the building has been carried out by Messrs. Defries and Sons, and the Electric Wire and Fittings Company show a variety of electric lamps.

Incandescent Lamps.—We are informed that Mr. F. Espir, of 3, East India avenue, Leadenhall street, E.C., has been appointed sole agent in this country for the Société Anonyme pour la Construction de Lampes à Incandescence of Budapest (the Budapest Incandescence Lamp Company) in view of the anticipated trade in imported lamps.

Agricultural Show at Dewsbury.—At one of the stands the Wray Electrical Engineering Company, of Bradford, show fittings necessary for the installation of electric light in a country house or a flour mill. The dynamo is worked by an oil engine. An Otto gas engine, by Messrs. Crossley Bros., Limited, is shown driving a Crompton dynamo.

Australian and Canadian Cable.—The laying of the Queensland and New Caledonia telegraph cable, which will form the first section of the projected cable between Australia and Canada, will shortly be commenced, and is expected to be finished by the end of August. The laying of the continuation to Vancouver will probably be completed within two years.

Coventry.—At a meeting on Tuesday of the City Council, under the presidency of the mayor, the Electric Light Committee recommended that they be empowered to employ a consulting engineer, but the mayor moved that before this was done the committee present a full report of their investigations up to the present time, and after some discussion this motion was adopted.

Coventry.—At a meeting of the Warwickshire County Council, the Roads and Bridges Committee mentioned that terms had been arranged with Mr. Graff Baker for the introduction of electric trams at Coventry, and as Mr. Graff Baker had now sold his interest in the tramways company, they recommended that the seal be affixed to an agreement with the new company.

Telephony between Belfast and Glasgow.—The postal authorities have arranged that parties desirous of communicating with Belfast by telephone may do so by applying at the public counter at the post office. The charge is 3s. for a conversation of not more than three minutes' duration, but the uninterrupted use of the wire may be secured for six minutes on payment of a double fee.

Electricity in Coal Mining.—The use of electricity in Welsh coal mines is on the increase. Blaennant, in the Aberdare Valley, is now electrically lighted, and at Abercanaid the Plymouth Collieries are illuminated extensively. Messrs. Crawshay have adopted the electric light for their colliery at Pontypridd, and it is stated that in the next winter Cyfarthfa Works will be similarly illuminated.

The Eastern Empire.—A new hall, built on the site of what was once Marlow's, is being opened this week in the East End of the metropolis. The hall is lighted by electricity from plant laid down in a roomy engine house at the back of the stage. Messrs. Vaughan and Brown, of 16 and 17, Kirby street, E.C., have carried out the installation in a very creditable manner, Mr. G. C. Vaughan, jun., having superintended the work.

Hampstead.—The tender of Messrs. R. A. Yerbury and Sons, of Kilburn, for the erection of a chimney shaft and buildings for the Hampstead central station, with foundations for the machinery, etc., in conformity with specifications and plans prepared by Mr. Preece, has been accepted for £7,350, and the tender of Messrs. Siemens Bros. and Co., for the supply of electric lighting plant, mains, etc., for the area at first to be lighted, has been accepted for £19,794.

Incandescent Electric Lamp Company, Limited.—This company has been registered by J. Fraser and Sons, 31, Copthall avenue, E.C., with a capital of £25,000 in £10 shares. The object is to carry on the manufacture and sale of electric lamps, fittings, appliances, and materials. There shall not be less than three nor more than seven directors. The first are J. Fraser, G. Binswanger, and C. J. Robertson. The qualification is £500.

Rugby.—On Saturday the Local Board received an application from the Rugby School Electric Lighting Company asking the Board to undertake the task of laying the cast-iron pipes for the cables where they crossed the public road, in order to avoid the difficulty of having to make good and maintain the surface of the road afterwards. The Board agreed to undertake the work, subject to their being relieved from all subsequent responsibility.

Lighting of Newspaper Offices.—The electric light installation in the offices of the *Yorkshire Post* is now complete, and consists of upwards of 400 incandescent lamps and four arc lamps. There are 200 lights in the composing department. The current is obtained from the Yorkshire House to House Electricity Company, and the scheme of the installation, with the specifications, was prepared and superintended by Mr. E. W. Lancaster, of Birmingham. The contract was undertaken by Messrs. S. Dixon and Son, of Leeds.

Bandon.—A public meeting was held on Monday to consider whether the Town Commissioners should oppose or consent to the application of the Bandon Electric Lighting Company for a provisional order. Mr. C. Crowley presided over the gathering. Mr. George Beare was opposed to the application, and he would propose that the ratepayers should instruct counsel to oppose the application made to the Town Commissioners. Mr. Sullivan seconded the resolution, which, after some discussion, was carried.

Blackpool and Lytham Tramways.—The Blackpool, St. Anne's, and Lytham Tramways Bill has been finally passed by Lord Morley's Committee of the House of Lords. The National Telephone Company and the railway companies asked for an amendment of the "model clause" inserted in the Bill on the recommendation of the Joint Committee, to the effect that the Board of Trade should have power to extend the time for the reconstruction of the system of wires. The committee decided to amend the clause, so as to give the Board of Trade power to extend the time.

Edinburgh.—At a meeting on Monday of the Edinburgh and Leith Gas Commission, a letter was read from the town clerk asking if the Commissioners would be willing to supply the Corporation of Edinburgh with gas for their engines, to be used in the production of electric light, at the same rate as they do at present for public lighting. The rate at which the gas would be supplied, it was pointed out in the letter, would be an important matter in coming to a decision whether they would use gas engines or not. After some discussion the matter was remitted to the Works Committee.

Lighting at Osborne.—In connection with the festivities at Cowes this week, her Majesty the Queen on Monday entertained a party of guests in the Indian-room, which in its splendid whiteness never looked so well as when illuminated by the many electric lights distributed in vases, bronze bowls, and in the exquisite "exhibition" set of Minton china and biscuit work, in which the turquoise blue contrasts so well with the delicate figures representing the four seasons and the pleasures of sport. The success of the electric lighting was due to Mr. Massey, the Queen's electrician.

A Reported Amalgamation.—It has been stated in several well informed quarters that an early amalgamation will be effected between the firms and businesses of Messrs. Goolden and Co. and Messrs. Easton and Anderson, Limited, though we do not know exactly with how much truth the statement is made, or what details, if any, have been settled. Probably the Woodfield Works are to be kept for the light manufactures, and heavier goods made at Erith. In view of the progress which ought to be achieved by electric traction in the early future, such an amalgamation—if it be a fact—should promise great success.

Derby.—On Wednesday, at a meeting of the Town Council, it was mentioned that Messrs. G. Fletcher and Co. had delivered three boilers under a contract in connection with the electric lighting works. The Highway Committee had approved of the proposed positions of the transformer boxes. The work of laying the cables has been commenced, and arrangements have been made with Messrs. Siemens for them to undertake the reinstatement of the pavement for the work they are at present doing, for £500. The Mayor requested the Council to adopt the minutes, which was seconded by Alderman Sowter, and carried.

Pontypool.—The surveyor reported at the monthly meeting of the Local Board last week, that the Pontypool Electric Light and Power Company, Limited, had completed laying their mains, but that they were rather dilatory in replacing the paving of the George street footpath. It was agreed that the surveyor call upon the company to replace the whole of the paving in accordance with their undertaking. The chairman read a letter from the Board of Trade, stating that they had received a certificate that the Pontypool Electric Light Company had expended the amount of money authorised by their license, and that they would release their deposit of £1,000.

Worthy of Consideration.—In one of our notes some time since reference was made to gas making apparatus. A correspondent from Sydney has written us on the subject, and from his letter we gather that there is room for the Dowson or some other system of the kind among consumers in Australia. Our correspondent, Mr. H. G. Masterman, of Victoria arcade, Sydney, consumes about 3,000 cubic feet of gas per day, for working a lift and getting the electric light: gas is 5s. per 1,000. We have forwarded another letter to the agent for the American system referred to in our note, but the opening is not blocked to Englishmen. Mr. Masterman says "there is a good opening for the invention here; if we put in the appliance there are plenty more would follow."

The Government and the Telephones.—In the House on Monday, Mr. Harry Foster asked the Postmaster General whether an agreement was now being settled between the Post Office and the National Telephone Company for the purchase by the Post Office of the National Company's trunk wires, or for the settlement of other matters. Mr Arnold Morley said the agreement with the National Telephone Company of 1892, with the Treasury minute of that year, was in the course of settlement, and in pursuance of the recommendations of the Select Committee would be laid before Parliament, but the committee were of opinion that the responsibility for the details rested with the Government, and he did not propose to lay it on the table before it was signed. The agreement would be on the lines of the minute.

Halifax.—When the members of the Halifax Flour Society met last Friday, the Secretary (Mr. Kendall) gave some important information as to the saving the society had effected by adopting the electric light. For 1892 their total payments for gas and the electric lighting amounted to £122. In 1890, when they had no electric light, their gas account was £174. There was thus a difference of about £52. That, however, was not all, as by putting in the electric light they effected a saving on their insurance of between £60 and £70 per annum. Mr Kendall added that the figures were all the more significant when they took into consideration that two years ago they ground 100,048 quarters, and last year 127,156 quarters. The use of gas, he said, was now almost confined to their stables.

Dundee.—In the course of his presidential address before the North British Association of Gas Managers, at the annual meeting in Dundee, Mr. T. Douglas Hall said that not only did Dundee possess fully and efficiently equipped gasworks, but there was a completely equipped electric light station, which had cost the Gas Commissioners, under whose control it was, about £30,000, and he was of opinion that the conclusion of the association, after they had visited both, would be that in respect of electric lighting Dundee was second to no other city. Without, however, condemning or attempting to justify the actions of public bodies, he said that electricity had not yet proved itself to be anything more than a luxury, while gas had become a necessity; and it was to be hoped that the Dundee Gas Commissioners in their wisdom would make the electric light department stand on its own legs, as in the case of gas, and that those who used electricity should alone be required to pay for it.

Grimsby.—The subject of electric lighting was discussed at a meeting last week of the Highways Committee of the Town Council. The borough surveyor intimated that he had written, in accordance with the request of the committee, to 47 places where the electric light was largely in use, with a view to getting information as to the advisability of illuminating the streets by electricity. He had received 16 replies, all within the last day or two, and was expecting more very shortly. The surveyor briefly went through the chief statements embodied in the letters received, one of which stated that the cost of electric lighting had been found to be three times as much as lighting by gas, and that the illuminating power gained was 10 times as great. On the motion of Mr. Jeffs, seconded by Mr Barrett, it was decided to adjourn the consideration of the subject for the present, the surveyor before the next meeting to supply each member, in printed form, with the chief items of the information then to hand.

Oriental Telephone Company.—The House of Lords has given judgment in the appeal in the case of Addison and others v. Ness. The question depended on the construction of an agreement made between the promoters of the Oriental Telephone Company, Limited, and the company itself, which was incorporated in 1881, with a nominal capital of £300,000 in £1 shares. The promoters were to receive a certain number of vendors' shares, fully paid up, as part satisfaction of the purchase money payable to them, the rest of the shares being ordinary. It was part of the agreement that during the first five years of the company's existence the holders of the vendors' shares should not participate in the profits of the company until the holders of the ordinary shares should have been paid a dividend of 6 per cent per annum. Mr. Justice Kekewich decided in favour of the appellants, who represented the ordinary shareholders, but his decision was reversed on appeal. Hence the present appeal. The judgment of the Court of Appeal was now reversed, and the respondent ordered to pay the costs.

Lighting of Hamburg.—We understand that a contract for the extension of the Hamburg electric light station and the distribution of electric energy over the whole area of the town has been given to Messrs. Schuckert and Co., Limited, of Nuremberg. It may be interesting to mention some particulars, as electricity will be used to a large extent as motive power. About 300 h.p. will be used for some tram lines in the town, and if this proves satisfactory, as is expected, all the tramways in the town, requiring about 1,000 h.p., will be operated by electricity. It is intended to connect the central railway station, which is to be erected, and which will require a large amount of current for light and power, with the generating station. In addition, 500 h.p. has to be provided for the working of cranes in the harbours. This is, however, not in connection with the free harbours, for which a large electric station was built in 1888 by Messrs. Schuckert and Co. A railway like the Berlin railway is projected for Hamburg, but to be constructed as a circular line, and it is proposed to use electricity as the driving power.

Southport Lighting.—On Wednesday a special meeting of the Town Council took place to consider the reports made by Mr. Wilkinson, electrical engineer, respecting the proposal for the electric lighting of a portion of the town. In his reports the engineer submitted two statements of capital expenditure required to carry out the scheme. The low-tension system he estimated to cost £13,255, which would mean the exclusion of Bold street, Promenade (from Bold street to Nevill street), and London street (from Chapel-street to Wright street) from the supply mains. The cost for the high tension alternating system, with station at Crowlands, was £13,297. The Gas and Electric Lighting Committee recommended the Council to adopt a proposal to supply the town area with electrical energy from generating plant erected at Crowlands. After a lengthy discussion, Councillor Dimond moved an amendment to the effect that the town area be supplied with electrical energy on the alternating current system from generating plant erected at Crowlands, and that tenders be invited for the building and plant. This amendment was put and unanimously carried.

Acton Hill Electrical Works.—The fifth annual sports in connection with the Acton Hill Electrical Engineering Works took place on Saturday in the grounds of The Elms, Acton Hill, by permission of Captain Ronald A. Scott. The weather was fine and the attendance was large. A committee, at the head of which was Captain R. A. Scott, superintended the sports; the other members were Messrs. Toy, Square, Turrell, Onslow, and Moore; hon. sec., Mr. Garrett; timekeeper, Mr. Hodgson. The course was on grass, seven laps to the mile, and the following are some of the results: 100 yards handicap—final heat: Fyson, first; C. J. Broomfield, second; Moore, third. High jump—H. Square, 5ft. 1in., first; J. H. McLaren, 5ft., second. Quarter mile handicap—H. N. Fyson (35 yards start), first; C. J. Bromfield (10), second. Long jump—H. Square, 17ft., first; E. H. Turrell, 16ft. 4in., second. Hurdle race (100 yards)—final heat: R. Needham, first; R. S. Walker (owes three yards), second; C. W. Barber, third; C. J. Bromfield (owes three yards), 0. Putting the weight—C. J. Bromfield, 31ft. 2in., first; E. H. Turrell, 30ft. 8in., second. Mile handicap—S. Chavasse (100 yards start), first; A. Smith (100), second; H. Hunt (120), third. The prizes were distributed by Mrs. Ronald Scott, and this brought to a close an enjoyable afternoon.

Glasgow.—The committee of the Town Council on electric lighting have had under consideration a proposal for the extension of the system. The scheme submitted contemplates the removal of the dynamos from the establishment in Waterloo-street to the premises in John street formerly occupied by Messrs. Mavor, Coulson, and Co., and now belonging to the Corporation, with the view of utilising them for supplying electricity for street-lighting purposes. This would leave room at Waterloo street for the installation of plant for the supply of incandescent light for house lighting, and for carrying out the necessary alterations it was agreed to recommend an expenditure of £5,000. The Corporation are at present supplying electricity for house lighting within the compulsory area, but mains have been laid down outside this area, and at the rate applications are coming in it would speedily become impossible to meet the demand. Provision will also have to be made for the lighting of Argyll street as soon as the railway operations permit, and for this additional power will be required. In the John street premises there are two powerful engines, with the necessary connections, which can at once be utilised, and which may meanwhile render unnecessary the acquisition of additional plant of this description. Some other questions have emerged for consideration, and the whole subject was remitted to a sub-committee.

Peterborough.—The question of lighting Peterborough by electricity was considered by the Town Council at the monthly meeting last week. The Lighting Committee stated that the engineer had reported upon the application of the Midland House-to-House Electricity Company for the consent of the Corporation for them to apply for a provisional order giving them power to supply electricity within the borough, whereupon Mr. Herbert proposed in committee the following resolution: "It being the intention of the Corporation themselves to eventually provide electric lighting for the city, we inform the Midland House-to-House Electricity Company of this intention, and object to their obtaining powers for this purpose." Mr. Hunting proposed that the engineer give a further report upon the points mentioned by him in his report, which was seconded by Mr. Manton, and carried. Mr. Miller moved the non-confirmation of the minute on the ground that it might lead the Council to assume a position which they were not likely to carry out. Alderman Redhead, who seconded, did not consider it was at all necessary for any report to be made upon the question. The Mayor said the question of electric lighting was being pressed forward in the town, and there was a very strong feeling amongst a considerable number of tradesmen that the time had come for electric lighting to be adopted, and they, as a Council, certainly could not stand in the way of such a feeling. The Mayor put Mr. Miller's amendment, which was defeated by 11 votes to four.

Shrewsbury.—The Town Council have held a special meeting to consider a communication from the Shropshire Electric Light and Power Company regarding the introduction of the light in the borough. The Mayor (Mr. G. Evans) presided. Mr. W. C. C. Peele attended as a deputation from the company. Alderman Southam said, as he moved the resolution in March, he would now propose the following: "That the resolution of the Council passed on the 9th day of March, 1891, in reference to an application made by the Shropshire Electric Light and Power Company, Limited, be and is hereby rescinded." This was seconded by Mr. W. M. How. After some discussion, the Council decided that the actual report of the borough surveyor on the information obtained by him should be read. The following are quotations: "It will be noticed that only two out of the 73 cities or towns in Great Britain—viz., Brighton and Glasgow, use water as the motive power for generating the light; in the others steam is used. "The

charge of the light to the several consumers varies from 9d. to 4½d. per unit. The former price is equal to gas supplied at 6s. per 1,000 cubic feet, and the latter at 3s. per 1,000 cubic feet. The average may be taken at 7d. per unit, or equal to gas supplied at 4s. 8d. per 1,000 cubic feet. The cost of fitting up of premises for the light will be much cheaper next year owing to the patent rights for the incandescent lamp dropping out. The lamps can then be purchased from 9d. to 1s., instead of 3s 6d. each, the present price. The damage and injury caused by gas to ceilings, pictures, and goods of every description should also be taken into account, and which reduces the cost of the electric light as against gas as an illuminant. A Special Electric Lighting Committee, appointed by the Vestry of the parish of St. Mary, Islington, in their report have gone very fully into the whole subject, and state in their opinion from the knowledge and information gained since its appointment that the supply of the electric light can no longer be regarded as a speculative business, but on the contrary, must be admitted to be an undertaking of great benefit to the public, and of assured commercial success. In conclusion, I strongly recommend your committee to seek an expert's opinion on a subject of so much importance to the borough and, from the statements before you, one that should if carried into effect, be remunerative as well as a comfort. Should your committee call in an opinion, I shall be pleased to give every assistance within my power." Further discussion then ensued, and on the motion being put, it was carried by 14 votes to five. Alderman Southam then moved the following resolution: "That the consent of the Council be and is hereby granted to the application of the Shropshire Electric Light and Power Company, Limited, for a provisional order to be confirmed by Parliament, power being reserved for the Council to purchase the undertaking at the end of 21, 28, or 35 years from the date of commencement of such provisional order, at a price to be agreed upon or fixed by arbitration." In doing so, he said as a very old Salopian, and as one who was anxious that the old town of Shrewsbury should keep pace with other towns of a like size, it was exceedingly desirable that they should not let the opportunity go by of having the electric light in the borough. Mr W. L. Browne, in seconding the resolution, thought they should offer every encouragement to the company to prosecute their undertaking, and he hoped they would soon see the streets of Shrewsbury lit by electricity. The resolution was eventually adopted.

PROVISIONAL PATENTS, 1893.

JULY 24.

14233. **An improved method of transmitting electrical calls or signals.** Thomas Joseph Gough, 33, Moseley street, Manchester.

14258. **An improved electricity meter for registering the amount of current consumed on direct or alternating circuits.** Frederick John Beaumont and Frederick Hallows, 37, Stockwell Park crescent, Brixton, London.

14259. **Improvements in dynamo-electric machines.** William Lawrie, 117, Bishopsgate street Within, London.

14271. **Improvements in the method of distributing electricity through sub-stations, and in apparatus for that purpose.** Charles Bertram and William John Hope-Johnstone, 70, Chancery lane, London.

JULY 25.

14298. **Improvements in the production of filaments for incandescent electric lamps.** Harry Kneebone Tomkins, 52, Whiteley-road, Gipsy hill, Surrey.

14315. **Improvements in galvanic elements.** Carl Wilhelm Adolf Hertel, 57, Barton arcade, Manchester. (Complete specification.)

JULY 26.

14422. **Improvements in apparatus for covering electric cables or conductors.** James Bassnett Atherton, 6, Lord street, Liverpool.

JULY 27.

14469. **Improvements in electric arc lamps.** Amos William Richardson, 6, Bank street, Manchester.

14474. **Improvements in the arrangement of telephone circuits and in apparatus therefor.** Sir Charles Stewart Forbes, Bart., 21, Finsbury pavement, London. (Complete specification.)

14481. **Improvements in ammeters and voltmeters.** Ernest Francis Moy and Francis Teague, 433, Strand, London.

14485. **Improvements in multiple point switches suitable for use in electric lighting.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 24, Southampton buildings, Chancery lane, London. (Complete specification.)

14486. **Improvements in electrically working armoured turrets, guns, and other apparatus, and in apparatus suitable for these purposes.** Sydney Pitt, 24, Southampton buildings, Chancery-lane, London. (Messrs. Sautter, Harlé, and Cie., France.) Complete specification.)

14489. **Improvements in or connected with turnstiles and electric counters connected therewith.** Ramon Chavarria Contardo, Norfolk House, Norfolk street, *London. (Complete specification.)*

14492. **Improvements in or in connection with electric conductors.** George Gatton Melhuish Hardingham, 191, Fleet street, London. (The firm of Felten and Guilleaume, Germany.)

14498. **Improvements in dynamo-electric generators and motors.** John Brokenshire Furneaux and George William Money, 46, Lincoln's-inn fields, London.

JULY 28.

14505. **A process and apparatus for obtaining pure metallic manganese by electrolysis.** Ludwig Voltmer, 11, Southampton buildings, Chancery lane, London.

14516. **Improvements in and connected with electric furnaces.** August Friedrich Wilhelm Kreinsen, 70, Market street, Manchester. (Complete specification.)

14525. **An improvement in relation to the covers for casings carrying electric light conductors.** Harry Christie Harold, 30, St. Swithin's lane, London.

14533. **Improvements in supplying electrical energy to motor vehicles on electric railways, and to electromotors on vessels by means of alternative current transformers.** Siemens Bros. and Co., Limited, 28, Southampton buildings, Chancery lane, London. (Messrs. Siemens and Halske, Germany.)

14534. **A cathode for electrolysis.** Henrik Christian Fredrik Störmer, 28, Southampton buildings, Chancery lane, London.

14556. **Improvements in apparatus for raising and lowering bodies, applicable, for instance, to electric and other lamps, and railway carriage and other blinds, and to hoisting gear.** Reuben Thomas Preston and Arthur Bernard Gill, 77, Chancery lane, London.

14562. **Improvements in alternate current dynamos and synchronising motors.** Henry Willock Ravenshaw and Llewellyn Birchall Atkinson, 1, Queen Victoria street, London.

JULY 29.

14628. **Improvements in or connected with cells or batteries for use in electrolysis.** Ferdinand Hurter, 47, Lincoln's-inn fields, London.

16335A. **Improvements in induction coils.** Edward Marshall Harrison, Monument chambers, King William street, London. (Date claimed under Patents Rule 19, Sept. 13, 1892.) (Complete specification.)

16335B. **Improvements in magneto electric generators.** Edward Marshall Harrison, Monument chambers, King William-street, London. (Date claimed under Patents Rule 19, Sept. 13, 1892.) (Complete specification.)

16335C. **Improvements in electric bells.** Edward Marshall Harrison, Monument chambers, King William street, London. (Date claimed under Patents Rule 19, Sept. 13, 1892.) (Complete specification.)

SPECIFICATIONS PUBLISHED

1892.

13297. **Electropathic appliances.** Horn. (Mears and another.)

13702. **Telephonic system for transmitting news.** Puskas.

14181. **Electric batteries.** Shrewsbury and Dobell.

16124. **Telephonic switching apparatus.** Bennett.

1893.

7387. **Electrically welding metals.** Thompson. (Coffin.)

9304. **Electric incandescent lamps.** Boult. (Waring.)

9779. **Electric switches.** Allison. (Electric Specialty Company.

10205. **Electric steering gear.** F. L. and L. H. Dyer.

10207. **Arc lamp electrodes.** Seibold.

10963. **Electro-mechanical switch, etc.** Clark.

11092. **Electric batteries.** Hellesen.

11105. **Electrolytic apparatus.** Craney.

11106. **Electrolytic cells.** Craney.

11107. **Electrolytic apparatus.** Craney.

11108. **Electrolysis of salts.** Craney.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¼
City of London	—	11
— Pref.	—	12¾
Electric Construction	—	—
Gatti's	—	5¼
House-to House	5	5¾
India Rubber, Gutta Percha & Telegraph Co.	10	22¼
Liverpool Electric Supply	5	6¼
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	6¾
National Telephone	5	4¾
St. James, Pref.	—	8¼
Swan United	3½	3¼
Westminster Electric	—	5¼

NOTES.

Ventilation.—The prevailing hot weather should do good to the suppliers of electric ventilating fans.

Welding Rails.—The rails of the West End Company, Cambridge, Mass., are being welded by electricity from a portable plant.

Gatling Gun.—An electric cartridge-feeder has been applied to the Gatling gun. This allows of an increase in the firing capacity.

Electrocution.—A burnt-out armature was the cause of the failure in the supply of current at the execution referred to last week.

Berlin-Koenigsberg Telephone.—The long-distance telephone between Berlin and Koenigsberg has been ready for some weeks, but is not yet in public use.

Sanitary Works.—The sanitary works at Rochdale are lighted by electricity, and, according to Councillor Hardman, they are the only works of the kind electrically illuminated.

South London Railway.—We are glad to learn that experiments are being made with a view to improve the illumination of the carriages on this railway. This is a step in the right direction.

Calais.—The port of Calais has long had electric light both on the lighthouse and at the landing-stage and hotel. The town of Calais is now to have electric light, as a central station is being built for M. Dehaynin.

Gaulard.—*L'Elettricità* gives an article by Prof. A. Volta on Luciano Gaulard, the pioneer introducer of the present transformer. A striking portrait of the unfortunate inventor accompanies this appreciative notice.

Storage Battery Patents.—A brighter outlook for the storage battery in America is thought likely after the judgment of Judge Coxe, recently pronounced, declaring void the Faure pasted-plate patent in the United States.

Liverpool Electric Railway.—This railway, during the 16 weeks covered by the accounts just issued to the shareholders, carried 1,370,742 passengers, or at the rate of 4,300,000 per annum. The service of the trains is very regular.

Mayence.—The General Electricity Company of Berlin and Messrs. Schuckert and Co., of Nuremberg, having approached the Mayence Town Council with a view to introducing the electric light, the latter is appointing a commission to consider the subject.

Nuremberg.—The Nuremberg Tramway Company intend to have their line run electrically. Instead of going to their own firm—Schuckert—they seem to have arranged with the Berlin Allgemeine Company for the equipment. It will be on the overhead trolley system.

Exhibition at Antwerp.—As mentioned in a previous issue, an international exhibition is to be opened at Antwerp next May. It is under the patronage of the King of the Belgians, and will comprise industrial, scientific, and artistic productions, as well as commercial produce.

Electric Power.—There is a growing tendency on the Continent to introduce electric power in engineering shops and in coal mines. At the Gutehoffnungshutte, at Sterkrade, all the machinery and tools in the bridge-building shop are operated electrically, and other works are about to follow this example.

New Caledonia Cable.—The cable for the submarine telegraph between Queensland and New Caledonia has been completed by the Société Générale des Telephones, of Calais. The steamer "François Arago," now at Calais, is being loaded, and will at once proceed to lay the cable.

Telephony.—Proposals are being made, not only in Glasgow, but also in Manchester, for a municipal telephone service. This is a step in the right direction, but it must not be forgotten that subscribers to local exchanges, in order to get inter-town communication, must also subscribe to the latter system.

Aluminium.—The French Electro-Metallurgical Company are about to start their aluminium works. Possessed of 30,000 h.p. in water power, they have sufficient for many extensions. They have only established conduits for 3,000 h.p., and will use but 1,000 h.p. at present, though machinery to utilise another 1,000 h.p. will shortly be put down.

Portable Installations.—A description is given in *La Lumière Electrique* last week of several types of portable electric light installations, by Messrs. Fein and the Schuckert Company. The waggons are very compactly arranged in fire-engine style, and a good feature is introduced in the tripod masts for arc lamps, which seem very convenient to handle.

Long-Distance Transmission.—An installation of electrical transmission of energy a distance of 28 miles at 10,000 volts, is to be found in the case of the San Antonio Light and Power Company at Pomona, California. Water power is used. The efficiency of the water-power plant is 83·5 per cent., of the electric system 63 per cent., and the total efficiency of the entire system is 52·2 per cent.

Electric Works.—*L'Electricien*, in its business supplement, has quite a list of electric works to be let and second-hand machinery to be sold in France. Amongst these offers is "a large central station of 3,000 lamps installed, with plant necessary to light 6,000 lamps; monopoly for 40 years. Orders for 4,000 more lamps in hand." This seems an enticing offer for a company wishing to invest capital.

Cologne.—Complaints having been raised by the customers of the Cologne municipal electric station as to the high cost of the lamps, the authorities have issued a pamphlet calling attention to the fact that many consumers use 25 c.p. lamps instead of the usual standard of 16 c.p. The municipality propose to sell lamps giving a guaranteed 16 c.p., and consuming 52 to 56 watts, at 8d. each. The demand for electric light under these favourable conditions will probably increase quickly.

Life of Incandescent Lamps.—From a tabular statement given in *L'Electricien*, it appears that the practical utility of lamps consuming little current per normal candle is very limited, and that as a general rule lamps which take from 3 to 3½ watts per candle are to be recommended. The conclusions to be drawn from the table are as follows: Lamps consuming 1½ watts per nominal candle last 45 lighting hours; those taking two watts, 200 hours; lamps consuming 2½ watts, 450 hours; and those taking three watts and 3½ watts, both 1,000 hours.

Electrolysis of Pipes.—The destruction of underground pipes by electrolysis by the action of currents from the electric railway has been noticed at several places in Hamilton, Canada. The *Canadian Architect* suggests the following protection as worthy of consideration and trial: "Wrap the pipe with a covering of tarred (pine tar) hemp about ½in. thick before burying it; give the outside of the pipe a thick coat, or two or three coats, of a good hard, but elastic japan which has been well dried in an oven; let the outside of the pipe be enamelled with an elastic enamel;

Electricity in Quarrying.—Experiments have been made in this direction during the past two or three years by Mr Edison. He quarries a low grade of iron ore, and lifts and transports it by means of two cable lines to the crushers. After being crushed, the material is gradually pulverised; then by an electric process the particles are separated from the particles of stone, and are compressed into bricks and sold as a high percentage iron ore. These operations necessitate the use of hoisting engines, drills, pumps, etc. The electric drill is being discarded, and the steam drill substituted.

"Faraday House Journal."—An electrical students' paper has appeared under the title of the *Faraday House Journal*, price 6d. monthly. It contains much writing, rather weak for the most part, on the training of electrical engineers, and has articles abounding in such expressions as "rot" and "dry up." This will distinctly appeal to student nature, while the immense advantages to parents of training their boys as "Faradians" and the value of "affiliation" are insisted upon and reiterated at full length. Sixpence seems a high price to pay for such material, but no doubt it is meant to be given away.

Electric Tramways.—It has yet to be shown what action the traction companies intend to take in view of the recent recommendations of the Joint Parliamentary Committee on electric traction powers. The clauses recommended by the latter have already been introduced in several Bills, and may now be accepted as model clauses, although in two or three cases the time has been slightly extended. The tramway companies are bound hand and foot so far as fresh capital expenditure is concerned, and it lies with the electric traction people and local authorities to set the ball rolling in this direction. Who will be the first?

Central Stations.—The *Elektrotechnische Zeitschrift* of the 4th inst. contains a long descriptive and illustrated acount of the central stations at Cassel and at Chur (Switzerland). At Cassel both alternate and direct current are used, the latter with Hagen accumulators. Oerlikon supplies the dynamos, and Siemens cables are laid. At Chur, as is now well known, alternate-current motors are commonly at work; the smaller motors are connected to the lighting mains, and the larger ones have special mains to supply them. Oerlikon machines are again used, and Girard turbines supply the motive power from the waterfall about 1½ miles from the town.

Cooking by Electricity.—An attempt is being made in Manchester to popularise the use of electricity for cooking purposes, and experiments in this direction have just been conducted at the offices of the Manchester Edison and Swan Electric Light Company. On the 4th inst. a dinner of five courses was cooked by electricity, the *menu* consisting of julienne soup, boiled salmon and shrimp sauce, veal cutlets and tomato sauce, leg of lamb, with French beans and potatoes, greengage tart and Victoria cream. The cooking was pronounced a complete success. In the kitchen the interesting operation of cooking by the new process was witnessed by a few privileged guests.

Storage Battery Traction in Paris.—In the course of a letter to a correspondent, sent in correction of some statements made by a Montreal paper, M Julien, of Brussels, states that horse traction in Paris costs 52 centimes for each vehicle per kilometre, while traction by electricity only amounts to 45 centimes. The horse cars, moreover, have only 48 seats, while the electric cars seat 56 persons, which makes, on the one hand, a decrease of seven centimes on the traction, and an increase in the receipts which may be put down on an average at 1f. 60c. per trip. Continuing, M. Julien says that as the car covers 115 kilometres and eight trips daily, the benefit is therefore 20f. per day for each car.

Waterloo and City Railway.—The directors of the London and South-Western Railway attach great importance to the Waterloo and City Railway, the Bill of which has passed through both Houses. Mr. Wyndham S. Portal, chairman of the former railway company, mentioned on Wednesday that the line would give the South-Western Railway easy access to the City, and that there would be a station near to the Bank and the Mansion House. The company which was to construct the proposed railway was independent, but the Act contained powers authorising the South-Western Company to work the line when it was finished. At their next meeting the terms of an agreement between the two companies would probably have to be discussed.

Prizes.—The Société Industrielle of Mulhouse offers for 1894 several medals and other prizes for papers or solutions of industrial problems. A medal will be given for an electric motor capable of developing variable speeds and powers at will ranging at least from one to ten, and presenting no variation of efficiency greater than 20 per cent. The power must be at least 10 h.p., and the efficiency equal to that of the motors now ordinarily in use. A medal will also be given for a paper dealing with the comparative cost of lighting a town of 30,000 inhabitants with gas and electric light. There are several other prizes, as, for instance, for any application of electricity to printing, for an instrument for determining the amount of water dragged by steam out of the boiler; for a registering totaliser of work done by an engine. Papers must be sent by February 25, 1894, to La Société Industrielle, Mulhouse.

Variation of Copper Deposition.—According to the law enounced by Faraday, the quantity of metal deposited on an anode by a given current should remain the same whatever the composition of the electrodes. This, however, is not so according to Herr Oettel, who states in the *Chemiker Zeitung* that with platinum electrodes the deposit of copper is only from 74 to 89 per cent. of that obtained with copper electrodes, the current being the same (0·13 ampere per decimetre square), and no hydrogen being given off. The cause of this divergence is the formation at the anode of persulphuric acid and hydrogen, which become diffused in the liquid, and on reaching the cathode are reduced, thus causing a reduction in the amount of metal deposited. The addition of some easily oxidisable substance, such as formic acid, annuls the action of these secondary products and increases the quantity of copper deposited to 98 up to 99·6 per cent. of the theoretical value. Alcohol is still more efficacious, and brings the deposit up to 99·9 per cent. of the theoretical amount.

Goebel Lamps.—The decision in the Goebel lamp case has been given, and is against Goebel's advocates, though their case stands better than before. At the last suit the judge thought it impossible to believe that a lamp should have been constructed by Goebel previous to 1877. This time Judge Leaman gives it as his opinion: "Against all of the improbabilities of this claim, the story as related by Goebel in his several affidavits, with detail confirmations by many witnesses, is interesting, circumstantial, and in many respects plausible." However, the burden of proof lay with Goebel, and the judge goes on to show where doubts existed, and decided that the complainant was entitled to an injunction. This is a victory for the General Electric Company. But it is felt that the want of liberal treatment has estranged so many companies that the rich royalties they might have

reaped are now past praying for. Many firms have brought out non-infringing lamps, and the lamp war is likely to wage as furiously as ever.

Smoke Consumers.—Inventions for prevention or consumption of smoke in boilers are almost innumerable, but the one recently brought before our notice by Messrs. Edwards and Wright has advantages which seem to promise good results. The practical trials bear out this promise, and boilers have already been fitted at Sheffield and elsewhere with very satisfactory effects. Certainly Sheffield could do with many smoke consumers, and London is not without desires in this direction. The apparatus is simple, consisting of a hollow iron bridge connected with a pipe, into which air is forced by a steam jet or a fan. The bridge itself is hot, and the pipe passing through the furnace is likewise heated, so that the air issues at a high temperature. On starting the boiler, thick smoke only issues for half a minute or so, and afterwards there is little or none to be seen. There is very little alteration to be done in fixing. The apparatus can be explained at the offices, 19, Laurence Pountney-lane, and seen at various boiler houses where it has been fixed.

Manufacture of Accumulators.—We do not trouble much about the disagreeablenesses of manufactures over here. A grumble about vibration or a too objectionable smell is the extent of our protestations. London is too smoky, too dirty, and too busy to worry about small beauties. In Paris it is different. With clean streets, fine buildings everywhere, and clear air, every factory is well looked after to prevent nuisance. The Paris Council of Hygiene has invited the Prefect of Police to give his opinion on the manufacture of accumulators. Working with oxides of lead and sulphuric acid, and giving off explosive fumes, should they come under "class 3"—lead foundries with special regulations? M. Michel Levy pointed out, with justice, that accumulator manufacture was a new trade and ought not to be too much fettered. Therefore, for the present every such factory is under the special rules, which allows each factory to be separately considered. The Council of Hygiene has wisely determined to gather a sufficient number of the results of experience before issuing any decided rules.

Prevention of Sparking.—The Déri-Blathy method of preventing sparking in alternate-current motors (or, as the writer conveniently terms them, alternomotors), is given in an article by M. F. Guilbert, in *La Lumière Electrique* for the 29th ult. The principle is simple, and consists in introducing a resistance, or, still better, a self-induction, in the conductors which connect the segments of the commutator to the sections of the armature. The armature may be of any form desired—drum, ring, or disc—and is wound as for a continuous-current machine, with the difference that the point of junction of the two consecutive sections is not connected direct to the commutator segment, but through a special circuit which has an appropriate resistance or self-induction, generally both of suitably-chosen amounts. These circuits diminish the current in the short-circuited coils. The resistance is chosen as low as possible while having high self induction. The coils may be wound on the armature itself or on a second laminated ring. Diagrams are given for ring and drum armature. The application seems to be intended for the continuous type of motor modified for driving by alternate currents.

High-Frequency Experiments.—We have already mentioned M. d'Arsonval's experiments with high-frequency currents. A description, with some diagrams of apparatus, is given by Dr. P. Oudin in *L'Electricien*, August 5. The sparks from a Ruhmkorff coil are allowed to pass between knobs—the stems being connected to the inside of Leyden jars. The two outside coatings are connected together by a high-resistance circuit, and from the ends of this circuit, near the coatings, wires are connected to two other knobs. It is the oscillatory current between these latter which are used. Sometimes the current is again passed into other coils of varying form. Enormous pressures are obtained, and ozone can be produced of a more intense odour than with any other apparatus. Dr. Oudin, at the end of his paper, mentions an experiment with a thermometer. Holding it by the reservoir, the upper end is placed in the spiral of wire thus energised. The upper part of the tube becomes irradiated in the thickness of the glass by a mass of small sparks of startling brilliancy. These at first short, penetrate deeper into the glass, and when one attains the outer face of the tube it at once goes out. The tube is then found to be very warm, and the body of it is rendered almost opaque by minute cracks in its substance.

The Thunderstorm.—A thunderstorm of great brilliancy, but apparently little damage, burst over London about one o'clock yesterday morning. The flashes of lightning were for more than an hour almost continuous, and sheets of lambent fire played about the heavens in unwonted splendour. It was extremely interesting to watch the varied nature of the flashes as they appeared to the eye. At first gentle bursts of silent flame illumined for a moment small patches of cloud. Then a broader sheet seemed to spread across the whole sky, against which the houses and trees became vividly outlined. Then, again, at other flashes the whole district seemed to be enveloped in a vivid violet smoke for the instant of the flash, the whole face of the landscape taking a violet tinge. As the storm came nearer, the hitherto silent discharges were accompanied by the sharp crash and long roll of the thunder, and the overflow discharge seemed plainly to be seen at some of the stronger flashes in a way that would please Dr. Lodge's heart. A blinding flash would quiver down the sky in a jagged curve; at once a secondary discharge took place at a certain distance away, and again a fainter flash, showing but a slight glow away on the horizon. This threefold discharge was often noticed, and was very suggestive. The storm followed a most oppressive day, and was certainly one of the most vivid recently seen.

Electric Interlocking.—M. Hubou read a practical paper on electric interlocking on railway lines before the Société des Ingénieurs Civils on the 21st ult. Electricity is especially useful, says the author, to interlock levers working separately or placed at long distances apart. By means of a Chaperon controller placed at the points, the signal which protects it may be locked. Electric bolts are also used. All the signal points along the route of the trains being furnished with electric bolts placed in series in the same circuit, the signals cannot be put to "line clear" except when all these bolts are locked in their normal place; and, conversely, the bolts cannot be unlocked until the signals corresponding, themselves fitted with electric bolts, are locked at "danger." Besides this these electric bolts can be controlled from a station by means of switches allowing the current to be sent or cut off, so as to allow or stop shunting operations. In the circuits pedals can also be inserted to complete the interlocking, so that if a train wrongly clears an open distant signal, the corresponding pass signal cannot be given. Electricity, adds M. Hubou, is usually employed in the form of continuous currents. But induction currents might also be used, and the mechanical transmission could be entirely

done away with by using electric discs. M. Hubou showed at his lecture actual models of the interlocking bolts and switch used on the lines of the Lyons Company.

Pacific Cable.—The even flow of the negotiations with regard to the establishment of a British cable across the Pacific to North America has been disturbed, says the *Daily Chronicle's* representative at Victoria, by the advent of the French company with its plans for a cable from Queensland to New Caledonia. Mr. Patterson, the Victorian Premier, has addressed a protest to the Governments of Queensland and New South Wales in that they have committed themselves to make a cable to New Caledonia, the first section of the Pacific cable, and thus assist in hindering the project for a British cable line to Vancouver by any other route. Mr. Patterson protested against being compelled to accept the New Caledonian route without consultation, and said he should be glad to learn that Queensland and New South Wales were still free to contract for a main Pacific cable otherwise than *via* New Caledonia. No reply has been received to these representations, but Mr. Patterson has written to the Imperial and Canadian Governments disclaiming responsibility for the selection of the New Caledonian route, and both the New Zealand and Tasmanian Governments have expressed agreement with the position he has assumed.

Telephone Statistics.—Some interesting particulars have been published in a French journal concerning the progress in telephonic communication during the past eight or nine years in Europe. At the close of 1883, Belgium and Switzerland had more telephones than any other country. Switzerland now has nearly 10,000 miles of telephone wires, with over 10,000 subscribers, who exchange about 8,000,000 communications in the course of the year. Belgium, in 1883, had telephones in six towns, and 2,300 subscribers, whereas now there are about 12,000 miles of wires with about 6,000 subscribers, who exchange upwards of 10,000,000 messages. In Italy the telephone was limited to six or seven principal cities, which, with a total population of two and a half million inhabitants, had 7,269 subscribers. Germany, in 1883, had 5,838 subscribers in the 33 principal towns, and has now about 70,000 miles of wires, with 49,531 subscribers exchanging about 257,000,000 communications. Denmark had only telephonic communication in Copenhagen, where there were 863 subscribers; and in Russia, where the telephone was confined to six or seven of the largest towns, there were only 2,000 subscribers. The principal towns of Holland had 1,718 subscribers, while in France there were 6,113 subscribers in towns the total population of which was rather over four millions. The progress in France since the State took over the telephones has been very rapid, and there are now about 20,000 subscribers for the 112 towns which possess telephonic communication, this being exclusive of the telephones from town to town.

Chimney Stacks for Central Stations. — The almost universal custom in this country as regards large chimney or smoke stack construction is to employ stone or brick as the material of which these structures are composed. It is perhaps typical of English solidity that tall chimneys should be built as though they were intended to endure for generations. American practice, however, has for some time now tended in the direction of using iron or steel for this purpose, and the reasons to be assigned for it are not unimportant. First of all they are constructed at a less cost and in much quicker time—doubtless the latter reason appealing specially to the desire to rush matters, which is rather too frequent in the United States. Then, again, the metallic chimney stacks are said to be much stronger in proportion, whilst they can be readily taken down if it is required. One would think, however, that the great variations in temperature would affect an iron or steel chimney to a much greater extent than brick or stone, whilst the æsthetic appearance of a cylindrical pipe is anything but charming, even when compared with the English "rounded pyramids." Moreover, it is hardly possible to attain a suitable height, and therefore draught, with a metallic chimney, so that a fan giving forced draught becomes necessary. In view, however, of the extensions which will take place in our central stations (as the demand for current increases), it may be worth while going into the question of chimney construction unbiassed by the conservatism of previous custom. The greatest objection would appear to be the cooling of the heated gases, so that a metal chimney might not give such a good draught.

Commercial Translations.—The London Chamber of Commerce has recently livened its methods by the starting on new journalistic ventures, determined to cater for an extended usefulness. There is another department of useful work to which we might draw attention, important alike to traders at home and abroad, which may perhaps commend itself to the committee. This is the preparation and translation of foreign circulars. It is a significant fact that the Imperial Austrian Commercial Museum (K. K. Handels-Museum, 11, Borsegasse, Vienna) have recently organised a department for this purpose, and will undertake to prepare and translate any circular in any ordinary language free of charge. This generous advocacy and aid to commercial enterprise cannot be without its effect, for many firms only hesitate to extend their market from want of knowledge of the languages. It may conceivably be worth the while of the London Chamber to do the same for our merchants. But without going so far as this, it might be pointed out that the Chamber's list of persons seeking positions always contain a number of men "thoroughly conversant with" French, German, Spanish, Swedish, Dutch, Portuguese, etc., as the case may be. While they are seeking other employment it is evident they would be willing enough to occupy themselves with translation of circulars or other work of this kind, under the Chamber, for moderate fees. If organised under competent supervision, and the work looked through by a native (such as for Spanish electrical technics, Senor Tolra, who already does this work at Adam-street, Adelphi), these unengaged persons might help themselves, the Chamber, and the merchants in a similar way to that done by the Austrian Handels-Museum, even if it were not possible to do the work entirely free of charge.

Potential of the Atmosphere.—What is the difference of potential between the air at the top of the Eiffel Tower and of the ground at the foot? This is the question, interesting alike to electricians and to meteorologists, which has been put to and the answer sought by M. Chauveau, of the Meteorological Department at Paris. The result is rather astonishing. One would expect a few volts difference of potential—even a few hundred volts. But the answer is 10,000 volts! This certainly seems extraordinary at the height of 1,000ft. only, yet on a recent visit to the Eiffel Tower one of our representatives saw the attendant at his tests, and the amount was then over 7,000 volts. A noticeable spark, clearly seen and heard in broad daylight, of some millimetres length, was taken from the outside knob. This apparatus is of the simplest, but accurate means of measurement are installed. A Thomson battery of several hundred volts as standard, a reflecting potentiometer, and a photographic register of the light spot are the means used for obtaining the curves of rise and fall of potential. Plotted against curves of thermometer, barometer, and hygrometer, this will probably tell an

interesting tale. The means of obtaining the potential of the surrounding air adopted is that, suggested by Lord Kelvin, of discharging fine streams of water. A small tube attached to a cistern of water projects out into the air for some 6ft. or 8ft. The tube and cistern are very carefully insulated, and a wire is led down to a knob within reaching distance, also highly insulated. On turning on the water-jet a fine stream of water floats away on the air; in a minute or two the whole apparatus, which has some considerable capacity, is charged and sparks can be obtained. In registering, a wire is carefully taken through into the dark room and registers automatically in the way mentioned. M. Chauveau devotes a good deal of time and attention to this interesting experiment, mounting the Eiffel Tower every day, rain or shine, and on some days in winter when the wind blows a perfect gale this is by no means a pleasant or even a safe task. In winter, of course, the reading is very difficult, for the water freezes, and the other way to obtain the potential, by means of a gas flame, is not less troublesome. Sufficient curves have been taken, however, to lead to interesting results. The potential rises and falls in well-defined curves, and very nearly a year's records have been obtained. The potential varies very much—from 3,000 to 7,000 volts is common—and on a brilliant, clear day at this time of the year 10,000 volts, we were told, was not uncommon.

The Hydrophone.—In a previous issue reference was made to this apparatus, which has been devised by Captain M'Evoy. Its object is to inform port authorities or a fleet of the approach of a torpedo-boat, even if the latter is entirely submerged. The following details of the apparatus will prove interesting: It consists essentially of two parts, one submerged in the sea at a suitable distance from the port or fleet to be warned, and at a depth sufficient to escape the surface agitation. This part may be described as an iron bell jar, which, on being plunged mouth downwards into the water, retains a volume of air in the upper portion or bottom, where a copper box, protecting the sensitive organ of the apparatus, is fixed. The organ in question is merely a very delicate vibratory contact, which makes and breaks an electric circuit connecting the submerged bell with the indicator or second part of the hydrophone, situated on shore or on board one of the ships of the fleet. The contact is formed by a flat horizontal spring, fixed at one end, and loaded at the other by a heavy piece of brass, having on its upper surface a small platinum stud. A fine platinum needle kept upright by a vertical guide rests its lower end loosely on the platinum stud. The needle and the stud are connected in the electric circuit through the guide and spring, and when the needle dances on the stud the circuit is made and broken. An electric current from the ship or shore battery is always flowing through the circuit—that is to say, between the submerged bell and the indicator. Now the propeller of a torpedo-boat or of a torpedo sets up vibrations in the water, and these, reaching the submerged bell, agitate the trembling contact, so that the needle dances on the stud and interrupts the current. The consequence is that the indicator begins to work and announces the submarine disturbance. This part of the hydrophone consists essentially of an electromagnet through which the current passes, with an armature free to oscillate when the circuit is rapidly made and broken—that is to say, when the current becomes intermittent. The motions of this armature can be seen by an observer if he chooses to watch, but actual observation is not required, for the indicator itself gives the alarm. This takes place when the swing of the armature carries it within the attraction of a magnetic contact-piece fixed near it. The armature is then drawn to the contact-piece and held fast there. The swing armature and the contact-piece are connected in the circuit of a local battery, and when they meet the current flows to ring an electric bell or light an electric lamp. The torpedo-boat thus announces its own arrival on the scene in spite of itself, and precautions can be taken against it. The hydrophone is at present undergoing a practical trial in the Solent, and the inventor estimates that three of the instruments suitably placed would be sufficient to protect Portsmouth Harbour. He is now engaged in constructing a larger bell than that already submerged, in order to meet the requirements of the Government authorities.

Action of Electricity on Microbes.—Attention has been called to the process of electrification for living bodies adopted by M. d'Arsonval, which consists in raising a current of very high frequency (800,000 per second) in a solenoid, into which the beings or the parts of their bodies to be experimented on are placed. By reason of the enormous induction developed in such a system, the bodies placed within the solenoid become the seat of currents circulating within their tissues and around each molecule at the frequency mentioned. The larger animals bear these currents without appreciable discomfort, and a man can easily bear energy to bring several lamps to incandescence. MM. d'Arsonval and Charrin have now attempted to find out how a microbe would stand the charge. One of the best known has been chosen—the pyocyanique bacillus—whose habits have been already well studied by MM. Gessard and Charrin. We do not know as yet much about the effect of electricity upon microbes. Important as the subject may be, it involves contradictions, as in ordinary applications it is often the heat or the gases liberated in a nascent state that act upon the germs. In these experiments, however, it may be taken that electricity pure is acting. A culture of the pyocyanogen bacteria is placed in the solenoid excited as above mentioned. Before the experiment two drops of this culture are placed in a tube, then the same is done after 10, 20, 60 minutes in a second, third, and fourth tube, and these four tubes are put to mature. A simple examination of these tubes shows that in all of them the bacillus germinates abundantly; the increase is about equal; its form does not undergo any great change, nor do its pathogenic functions. But the power of secreting pigments is modified: while the first two tubes show an intense blue-green tint, hardly at all lessened in the second, the last two show the greenish tint much less accentuated. There is no doubt the chromogenic power of the bacillus has been affected. Thus it is demonstrated that we have another agent, electricity—for heat, light, and movement have already been studied—which may act upon the bacterial world—in short, upon living cells; and it is thus understood how the electric state of the atmosphere may exert an influence upon the germ diseases, upon epidemics which are known to depend to some extent upon cosmic conditions. MM. d'Arsonval and Charrin also point out that this electricity also affects the vitality of our own bodies, and consequently the gravity or otherwise of certain diseases. We well know, even in the present state of our knowledge, of the influence of thunderstorms on certain ferments—on the lactic ferment, for instance; for every dairymaid knows that "thunder turns the milk sour" This discovery of MM. d'Arsonval and Charrin of the influence of electricity on the chromogenic function of bacilli may therefore be the first of a series which will eventually enable us to generalise upon the mutual interdependence of climatic conditions, and the spread and, it is to be hoped, the prevention of disease.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

(Continued from page 79.)

INCANDESCENT LIGHTING.

The light given off by the second kind of electric lamp—namely, the incandescent or glow lamp—is really due to the same cause as that which produces the arc light—*i.e.*, carbon raised to an incandescent or glowing state by means of electric energy. In the arc lamp the crater is white hot carbon, and in the incandescent lamp the whole of the filament is made white hot. The reason why the light of an incandescent lamp is so much below that of an arc lamp is because the carbon filament of the former is only raised to about the temperature of melting platinum, say 1,800deg. C. or 2,000deg. C., whilst the crater of the arc is raised much above this, perhaps up to 6,000deg. C.; certainly not below 3,000deg. C.

The incandescent lamp, as is generally known by this time, consists of a very thin thread of carbonised fibre, technically called the "filament," hermetically sealed within a pear-shaped glass bulb, which is exhausted of air as much as possible. The filament is bent parallel, somewhat after the manner of a hairpin, and sometimes has a curl at the bend. The two ends of the filament are jointed on to two platinum wires, which pass, embedded, through the neck of the bulb and make contact with two brass terminals. These terminals are fixed in plaster of Paris, thus forming a terminal collar to the lamp. Unlike the arc lamp, the incandescent lamp is seen to its best advantage for indoor illumination, and being of small candle-power the light can be distributed in any way desirable, and fixed in any place.

Illuminating Powers.—For the same amount of electrical energy spent an arc lamp will give from eight to nine times the amount of light that an incandescent lamp will give. An arc lamp gives, say, 1,000 c.p. for 400 watts; this is at the rate of 2·5 candles per watt, or ·4 of a watt per candle-power. An incandescent lamp of 16 c.p. absorbs, say, 56 watts, and this is at the rate of ·28 candle per watt, or 3·5 watts per candle-power. These lamps are made with a great variety of candle power, and also to burn at various pressures. The standard size is a lamp of 16 c.p. to run at 100 volts pressure, because this is the most common pressure adopted in consumers' houses. The same sized lamp can, however, be made to run at a higher or lower voltage, such as 50 volts or 120 volts. For indoor illumination, 8 c.p. and 32 c.p. are also greatly used, the smaller one being very useful for lighting places that do not require much light—such as corridors, stair cases, small rooms, recesses, etc.; the larger light is useful for places where an extra illumination is required—as shop windows, billiard tables, etc. The very large sizes—as 100, 200, and 500—are known as "Sunbeams, and are mostly used for lighting large rooms, entrance halls, or outdoor. These lamps are not used very much because their "life" is not long, and they blacken and decrease rapidly in candle-power. In addition to all the above, there are very small lamps of five, three, two, and half candle-power—3 c.p. is generally found in miners' electric hand lamps, where the lamp is connected up to an accumulator battery. The smallest lamps are used in theatrical effects, and in surgical and such like operations.

A lamp of same candle-power and efficiency consumes the same energy whatever voltage it may be made for, because the lower the pressure the greater must its current be. For example, a 16 c.p. lamp at 100 volts pressure has a filament of about 180 ohms resistance, and will therefore take a current of $100 \div 180 = \cdot 55$ of an ampere. Suppose a similar lamp is required to run on a circuit which is at a pressure of 50 volts, evidently at this pressure only half the current would flow through the filament: therefore to have the same current the resistance of the filament must be halved, and this means doubling the sectional area. But although we have now the same current, we only use half the pressure, consequently only one-half the electrical energy, or number of watts, because $50 \times \cdot 55$ is one-half of $100 \times \cdot 55$. To get the same quantity of light we must utilise the same amount of energy. By again halving the resistance, or again doubling the sectional area of the filament, we get 1·1 amperes through, and then $50 \times 1 \cdot 1$ equals $100 \times \cdot 55$; so that to run a lamp at half the voltage requires double the current, and the filament will have four times the sectional area, or double the diameter. Generally, then, as the working voltage decreases, the diameter of the filament increases. It is very easy to distinguish between an 8 c.p. and a 16 c.p. lamp when the candle-power number is illegible: the 8-c.p. lamp has a much finer filament than the 16 c.p. when both are made for the same voltage. The tabulation below gives the current that various sized lamps take.

TABULATION 23.

Candle-power.	Volts.	Amperes.	Watts.
1	2 8	1·5	4·2
2	25	·32	8
5	50	·4	20
8	100	·32	32
16	100	·56	56
32	100	1·12	112
50	100	1·75	175
100	100	3·5	350
200	100	7·0	700
500	100	17·5	1,750

Of course there are a number of other pressures that lamps are made for besides 100 volts, but that is the most common one for incandescent lamps. Where storage batteries are employed in conjunction with machinery at private establishments, the circuit pressure is often fixed for 50, 60, or 70 volts. Then there are lamps made for 105 and 110 volts.

A lamp should only be run at the voltage for what it is made. If this be not done, then when the voltage is lower the light will fall off enormously, and when the voltage is higher the light will be enormously increased, but the lamp will be quickly burnt out. To show how rapidly and out of proportion the light of a lamp varies when its voltage, and hence its current, is varied, the figures given below are the result of an experiment made on a 50-volt lamp of 16 c.p. taking 52 watts.

TABULATION 24.

Volts.	Candle-power.	Watts.
25	·4	14·0
29 5	·87	19·
34 8	2·47	26·9
40·0	5 1	35·9
48·0	12·6	46 3
49·0	15·0	50 5
50·0	15·8	52·7
52 5	20·5	57·5
52 6	28·4	64 5
59 5	39·3	72·9
62·0	50·7	79 9
68·2	74·5	96·7
72·5	103·2	107·5

By studying the above figures it is seen that when the voltage has fallen two volts, or 4 per cent., the light has fallen no less than 21 per cent., or more than one-fifth. Approximately, the variation of candle-power is in proportion to the sixth power of the voltages—this is limited to within about 20 per cent. below and 20 per cent. above the normal candle-power. Numerous empiric rules have been formulated for expressing the rise and fall of candle-power in terms of the voltage, but none of them are of much service for practical purposes, and the rough rule given above will be found sufficient for most purposes. Upon applying it to the example just quoted, it will be found that it holds true and is almost exactly correct, for the ratio between the sixth powers of 48 and 50 is about 4 : 5, and four-fifths of 15·8 works out 12·6; similarly the ratio of the sixth powers of 50 and 52·5 is about 3 : 4, and 15·8 multiplied by 4 and divided by 3 gives 21, which is near enough to 20·5 given by the table.

An incandescent lamp of 16 c.p. will illuminate well a floor area of about 50 square feet when placed, say, 10ft.

high, and will give a good ordinary light for every 80 square feet. A large percentage of the light goes upward when the lamp is fixed with its holder uppermost, and when the lamp is fixed on a table standard, or on brackets, so that the bulb is upwards, more light goes upwards than downwards. So it is essential to use reflecting shades if it is required to direct the light in any way and obtain its full benefit, such as for reading purposes, workshop benches, and all places where each individual wants a small light to himself. It is in this case that the advantage and superiority of the incandescent is mostly proved over every other kind of light—even the arc lamp is then at a disadvantage. The lamp suspended by a flexible cable can be raised and lowered, as desired ; it can be placed within an inch or so of any work to be examined, and when provided with a hand support and length of flexible cable can be placed and carried about anywhere. For reading, perhaps the pleasantest kind of shade is green porcelain having a white enamelled interior surface. Rooms and halls having whitewashed ceilings require less illuminating power than those which have not. Similarly, rooms with light coloured wall paper reflect more light than those with dark coloured paper.

The illuminating power of all incandescent lamps deteriorates with duration of burning, and the longer they burn, the more their light is diminished. When the lamps have reached a certain stage of dimness, it is uneconomical to keep them burning, and they should then be replaced by new lamps, the old ones being either broken or placed in some unimportant place where a decreased light is of little moment. A great deal of the deterioration of the light is certainly due to the blackening of the inside of the glass bulb, caused by the gradual disintegration of the carbon filament, which action deposits a fine film of carbon on the surface of the glass. There are one or two other causes, such as the thinning of the filament as it disintegrates. This increases its resistance, and so helps to diminish the light ; beyond this there is not much knowledge on the matter : it is suggested that the vacuum becomes less perfect. To retain the initial illuminating power of a lamp is the most important problem to solve in their manufacture, and to effect this the filament must be made durable, and able to withstand high temperatures. The glass bulb is made either clear or clouded : in the former case the filament is exposed to the eye, and is painful to look upon, owing to its intensity ; by having the glass clouded or frosted the filament is hidden, and the light is diffused over the bulb, hence giving a subdued and more pleasing effect. Any loss of light that may result from this kind is amply compensated by the increased comfort their use confers.

Life and Efficiency.—The average life of a 16-c.p. lamp is estimated to be close upon 1,000 hours. A few break in a few hours, but this is very seldom, and they are defective lamps ; others have various lives, ranging from hundreds to over 1,000 hours, whilst others, again, have been known to last over 3,000 hours, but the majority of lamps work out to an average somewhere about 1,000 hours ; hence this number may be taken when making calculations respecting their running costs. The following figures show how the candle power falls off in different stages of their life, being the result of tests made at Cornell University on a 16 c.p. lamp worked at 100 volts pressure ; the decrease of energy consumed is also given :

Tabulation 25.

—	At start.	100 hrs.	200 hrs.	400 hrs.	800 hrs.
Candle-power	16	12·5	10·8	9·67	7·2
Watts	48·24	46·21	45·9	43·61	42·33
Watts per c.p. ..	3·01	3·69	4·25	4·51	5·88

The efficiency of an incandescent lamp is often interpreted as the rate of initial electric power it consumes in comparison with the initial light given out ; thus, a lamp which takes only 40 watts, and gives 16 c.p., when new is termed a high-efficiency lamp, whereas a lamp that takes 64 watts, and gives 16 c.p., is termed a low efficiency lamp. Normal efficiency being generally granted when a lamp takes 54 watts, or 3·5 watts per candle-power. The term efficiency when employed in this way is very misleading, because, although a so called high efficiency lamp only consumes small power at the commencement of its life, it unfortunately has a short life, and the candle-power diminishes very rapidly; and the smaller that this initial power is, the shorter becomes the life of the lamp, and the more does its light diminish. On the other hand, by using a so-called low-efficiency lamp, the large consumption of initial power is accompanied by a long life, and only a small decrease of candle-power.

There are, then, three chief factors that enter into the real efficiency of the lamp, and these are : (1) life of the lamp ; (2) mean candle-power ; (3) mean power used. These factors depend on the way in which the lamps are manufactured, and when run at the pressure which the maker recommends, the resultant will give the true efficiency of the lamp, judged as a machine for converting electric energy into light ; and hence its efficiency is the ratio existing between the total amount of electric energy consumed during its life, and the total quantity of light given out during its life, so that

total energy = mean watts × hours of life ;
total light = mean candle-power × hours of life ;

$$\therefore \text{efficiency} = \frac{\text{watt-hours}}{\text{candle-power hours}}.$$

This efficiency may be expressed as so many watts per candle-power. If the lamp be run at other pressures than what is recommended by the manufacturer, whether slightly above or slightly below, different efficiencies will be obtained. The relations between working pressure and efficiency provide a subject for most interesting and elaborate calculations, and forms a neat example of the "maxima and minima" order of problems, because, as mentioned previously, running a lamp at a slightly higher pressure than what it is made for will give a large increase of light at the early part of its life, but the light will diminish rapidly, and the life of the lamp will be considerably shortened.

The following data gives the results of experiments that have been made with the greatest care and every precaution by Messrs. Siemens and Halske, of Berlin, and they show in the most emphatic manner that those lamps that are run with a small initial power are not efficient, and that those which consume a smaller initial power are the most efficient in the long run :

Tabulation 26.

–	A.	B.	C.	D.	E.
Initial watts per candle-power	1·5	2·0	2·5	3·0	3·5
Final ,, ,,	3·65	5·24	5·47	5·27	4·32
Initial candle-power	16	16	16	16	16
Final ,, ...	5·8	5·2	6·6	8·4	12·5
Life in hours	45	200	450	1,000	1,000
Mean watts per candle-power...	2·85	3·69	4·21	4·04	3·85

(To be continued.)

ON THE ELECTRIC LIGHT OF LIGHTHOUSES.*

EXPERIMENTS MADE BY THE LIGHTHOUSE DEPARTMENT OF FRANCE.

BY ANDRÉ BLONDEL.

(Concluded from page 107.)

Choice of Carbons, Diameter, and Separation.—For the same reason as with continuous currents, we employ the hardest possible carbons. The specific resistance of "Carre" carbons, which give excellent results, increases with the diameter ; it may be estimated on an average at 7,000 to 8,000 microhms. The smallest admissible dimensions, and consequently the most satisfactory, are indicated in the preceding table. They correspond to currents of 0·315, 0·25, and 0·24 amperes per square millimetre.

This current density might be further increased, and consequently the diameter diminished, by the employment of carbons lightly coated with copper (1/5th mm.), so that the melting of the copper may not produce any accidental shunt circuit, followed by extinction.†

* Paper read before the International Maritime Congress, London meeting, July, 1893.

† The greatest difficulty is to manufacture carbons of diameter greater than 20mm. sufficiently homogeneous to support the passage of the current without cracking transversely. The researches on this point made by M. Carre and Le Carbone Co. encourage us to hope for some success shortly in this direction.

The arc cannot be made longer than 10 mm. to 15 mm. without producing a large flame; besides, we cannot increase the distance apart without at the same time increasing the difference of potential, and consequently the work expended at constant current. Geometrically it appears sufficient to separate the parts raised to the maximum brightness until the distance is equal to half the diameter of the terminal faces, or about a quarter the diameter of the carbons, that is to say, to 6mm for arcs of 100 amperes. The two foci of bi focal lenses being at 1cm. apart, we are thus assured that the focal rays pass through the incandescent portions. The corresponding pressure, which is about 45 volts, has been allowed for all the currents, in order not to complicate the service, whilst realising the maximum power of the De Meritens machines at the speed of 550 revolutions. To determine directly the best distance between the carbons, a series of experiments should be made with the same intensity of current. These might be undertaken with the help of the new alternators with variable exciting current, whilst hitherto it has been impossible to make them with the De Meritens machine. The measurements made on this point at the Lighthouse Department, France, have only availed to establish that in bi-focal lenses, and with magneto machines, the actual

Magneto Electric Machines of De Meritens.

It is known that these machines comprise five armature rings, each revolving in the interior of a corresponding ring of electro-magnets. The coils are equal in number to the magnet poles that is to say, 16 in the French lighthouses (Type C) and 24 in the English lighthouses (Type 1)* They constitute so many independent elements that can be coupled at will in series or in parallel.

In the French lighthouses, according to different experiments, the old coupling, corresponding to a speed of 900 revolutions, has been definitely abandoned, this speed being too high by reason of the defective mode of lubrication of the machines, and it has been reduced to about 450 (raised more recently to 550). In these conditions each machine is composed of two circuits having each five groups of eight coils in series that is to say, the half of each ring coupled in parallel. These two circuits each end in two insulated rings, keyed on to the shaft of the machine. At the speed of 450 revolutions each machine is capable of giving, with a difference of potential of 40 volts, a current of 22·5 or of 50 amperes, according as one is used or two. At the speed of 550 revolutions we obtain the same intensities with a pressure of 55 volts.

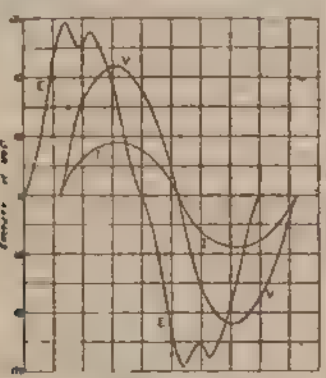

FIG. 10.—Periodic Curves of the De Meritens Magneto.

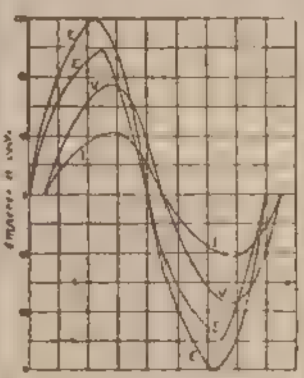

FIG. 11.—Periodic Curves of the Siemens Labour Alternator.

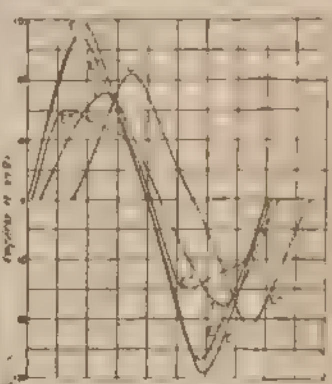

FIG. 12.—Periodic Curves of the Labour Alternator.

E. Electromotive force of one circuit the other being open. E'. Electromotive force of one circuit when the other has its normal current, I. E''. Electromotive force of one circuit when the other is closed in short circuit. I. Normal intensity. V. Difference of potential at the poles. C. Current in short circuit.

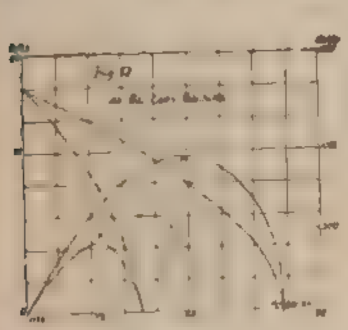

FIG. 13.

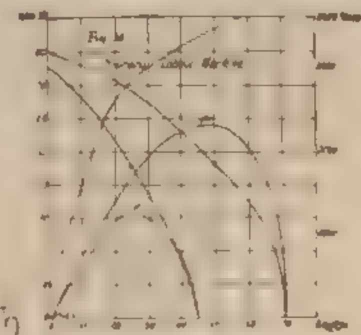

FIG. 14.

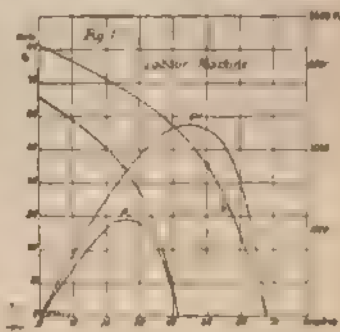

FIG. 15.

currents [illegible] higher than those that would be obtained by increasing the separation, as the following table shows:

Diameter of the carbons.	Distance apart.	Intensity.	Pressure.	Electric power. Apparent.	Electric power. Corrected.	Luminous power.	Efficiency per watt.
mm.	mm.	amp.	volts.				
16	5	50	45	2,250	2,140	1,925,000	900
16	15	45	50	2,250	2,140	1,140,000	532
10	4	25	45	1,125	1,069	1,110,000	1,032
10	[illegible]	[illegible]	47	1,080	1,026	1,014,000	980
10	8	19	52	988	939	720,000	771

But these conclusions would not necessarily apply to different types of machine or optical apparatus.

Alternate Current Machines. Properties and Results Obtained.

According to the preceding remarks the electric conditions which a type of alternator must fulfil in order to be perfect for the service of a French lighthouse are as follows: To furnish at will currents of from 25 to 100 amperes; to bear without disturbance a sudden or prolonged short circuit; to enable the power to vary in the neighbourhood of the normal condition in the same sense as the intensity or that it shall pass through a maximum; to give an open circuit an E.M.F. of at least 70 volts, and, lastly, to have a frequency of at least 40 to 50 periods per second.

We shall now see how the different machines answer to this programme, beginning with the De Meritens machine as the best known, and, we may almost say, as the only one hitherto employed.*

Properties.—The periodic curves of Fig. 10 represent the laws according to which the induced E.M.F., the difference of potential at the terminals, and the intensity under different conditions vary during each period. The well marked double summit of the E.M.F. arises simply from the fact that the magnet poles are much wider than those of the armature. It disappears from the curves of intensity as soon as the current becomes somewhat strong.

Currents.—Fig. 15 represents the external characteristics of a complete machine at the speed of 450 revolutions, and consequently the series of currents that it can furnish at the terminals when the external resistance is varied.†

When a half machine is working alone, the conditions in which the eight bobbins utilised for each ring are placed are not exactly the same as when the two circuits are closed because of their mutual induction. This difference shows itself in a certain reduction of intensity. Whilst we obtain 25 amperes at 40 volts in each circuit when they are working together, we only obtain 22·5 amperes at 40 volts with one of them separately.

Power.—The apparent power, E I, varies according to a law represented as a function of the intensity of the current by two curves deduced from the characteristics Fig. 13. These curves have maxima corresponding to the two normal currents, 25 and 50 amperes. If we neglect subordinate phenomena of small importance, these currents correspond also approximately to the maxima of the mechanical power required from the motor. Also, owing to the important effects of hysteresis, and, above all, of

* Zipernowski's machines have been, nevertheless, recently installed at the Campan Lighthouse.

* D. V. Reports on the experiments at South Foreland. Part II., p. 20.

† The curves have been drawn taking for the resistance either a liquid rheostat or an arc. No sensible difference has been found between the two cases, although the power expended in the arc is no longer equal to the apparent power, as we have said above. The characteristic of supply at the terminals of the lamp is deduced from the former by subtracting from its ordinates the pressure absorbed by the resistance of the wires, neglecting self-induction. The regulating coil in series absorbs less than 1 volt.

Foucault currents, which arise in the armature and the electro magnets, through their being insufficiently laminated, this power varies very little from one current to the other and this further contributes to increase the steadiness, and to destroy any tendency to racing when the current is interrupted. The work on open circuit is, in fact, not less than 2 h.p.

Efficiency.—The considerable losses cause the efficiency to be wretched with small loads but they diminish very rapidly as the armature is traversed by a current, its magnetic action being, as we know, opposed to that of the electromagnets. Experiment made long ago at the Lighthouse Establishment, France gave, with the 50 ampere current, an efficiency of 0·77, which is not far from the 0·80 obtained at South Foreland.* For the current of 25 amperes the power is one half less, the subsidiary actions being on the contrary increased, and it is not surprising, then, that the efficiency is reduced to about 0·54.

Coupling.—The two De Meritens machines of a lighthouse may be coupled in parallel either by means of mechanical gearing or electrically, as Dr. Hopkinson first showed to be possible in his lecture before the Institution of Civil Engineers, and as Prof. W. Grylls Adams first showed practically in his experiments with the De Meritens machines at the South Foreland. Since this demonstration electrical coupling has been tried in a certain number of French and other lighthouses. If the pulleys are quite equal, and the belts equally and moderately stretched, the two machines synchronise of themselves, and retain their synchronism for an indefinite time.

Without giving up the benefits of electrical coupling, the chief of which is its not demanding any stoppage of the machine, it is prudent, looking at the disadvantageous conditions in which the synchronisation is produced, to have a mechanical method of coupling in reserve to which recourse can be had whenever the former appears insufficient;† that is a solution adopted in the new installation of the lighthouse at La Hève. The mechanical coupling adopted, made by the house of Sautter, Harlé and Co., is combined with a system of two loose pulleys placed between the fixed pulleys of the dynamos, and it can be operated without interrupting the working of the machine which is already in operation.

Advantages and Defects.—These machines, which for 12 years have not given rise to any accident, are remarkable above everything for their qualities of safety and regularity. Their mode of lubrication might be easily improved. From the electrical point of view, thanks to their great mechanical inertia, to the constancy of their magnetic field,‡ and the form of their characteristic, they give very steady arcs, and support without inconvenience a short circuit of which the intensity is not above 80 amperes. The subsidiary actions themselves, as we have seen, are beneficial in certain respects. As to the efficiency, it is not much inferior at the current of 50 amperes to what can be obtained with machines of such small power. The small value with the 25 ampere current only employed during a small part of the year (20 per cent. at the La Hève Lighthouse) does not play a very important part in the annual expense, and besides, all the machines with two currents show always more or less the same defects.

The only defects which may indisputably be ascribed to the De Meritens machines arise from the employment of permanent magnets. These are their cumbrous size and their price. The price (9,000f.) is very high compared with that at which we find to-day the equivalent alternators of commerce (from 3,000f., including the exciter). It is for this reason that a type of machine has been sought with alternate currents presenting the same electrical properties, and, therefore, the same practical qualities.

Alternate Current Dynamos intended to Replace the Magnetos of De Meritens.

First Attempts.—The first solution, which consisted in the employment of a single machine capable of furnishing three currents of 25, 50, and 100 amperes, by a simple modification of the exciting machine was attempted in 1889 without success. The machine was of the Siemens type, properly so called, with an apparent internal resistance extremely small. Its characteristic was almost horizontal, and could give no stability; nevertheless, three good characteristics, with sufficient slope, might have been obtained by the help of the machine by exciting it at 70 volts at least on open circuit, and interpolating in the circuit self-induction coils proportioned to each current. The latter play, in fact, for alternate-current machines, the same part as the rheostat does for continuous current machines, with this difference, that they absorb scarcely any energy. Several attempts made in this direction have given good results, and have shown that we may obtain in this way not only three sloping characteristics, but also three currents of maximum power at 25, 50, and 100 amperes without the intensity and short circuit ever passing $1\frac{1}{2}$ to 2 times the normal intensity. Thanks to this contrivance, any alternator whatever of the ordinary types might supply an arc lighthouse with steadiness, but the efficiency would be unsatisfactory with lower currents, and a machine has been preferred, as said above, with two currents; only it was proposed, as said above, to obtain them by two independent circuits, as in the De Meritens machines, to which the attendants are accustomed.

Alternator without Core, having Separate Exciter.—The Siemens type without core was that which at the outset appeared to lend itself best to this combination, because the subsidiary action, already weak in it, enables us easily to calculate beforehand the self induction of the machine, and to avoid the reactions of one of the circuits on the other.

A machine of this type established according to the programme sketched out was constructed by the "L'Eclairage Electrique" Company on the plans of M. Labour, their engineer, and underwent in 1891 prolonged trials at the Lighthouse Establishment (France). The alternator and its exciter, Fig. 16, are mounted side by side, so that their two shafts may be coupled and driven by a single pulley carried by the shaft of the alternator. To facilitate the throwing in and out of gear, the shaft carries a loose pulley with a grease cup. The exciter is a Rechniewsky continuous current machine, excited in series, whose armature is toothed so as to reduce to a minimum the magnetic resistance of the air gap, and consequently the cost of exciting, and of which the electromagnets are built up of sheets in order to reduce to a minimum the Foucault currents and the consequent loss of energy. The Siemens-Labour alternator, similar in type to the ordinary Siemens in its general arrangements, is distinguished from it by the manner in which the armature coils are mounted and wound. These are made with a conductor, not of thin plates, but of insulated wires, which allows the number of turns to be increased, and the losses by Foucault currents to be diminished. The coils are eight in number, like the pairs of magnet poles. They form two circuits, each comprising four of them (two in series and two in shunt), and leading to three collecting rings, of which one forms a common return.

To obtain in this machine a sufficient self induction, as well as the condition of maximum power, a great quantity of copper must be put in the armature, which has consequently a great resistance, and the magnetic field must be reduced to a comparatively small value. The following statement includes the principal data of its construction, which designedly departs from ordinary conditions:

Data of Construction.—Speed, 800 revolutions; frequency, 53·33 periods. Armature wire of 1·8mm., 120 turns per coil; resistance and self induction of one circuit, 0·41 ohms and 0·006 henrys. Electromagnets, wires of 4mm. 130 turns per electro; resistance, 0·85 ohms. Air gap length 19mm.; section per coil, 73 square centimetres. Magnetic field, about 1,600 C.G.S. Intensity of exciting current, 10 to 11 amperes.

The industrial efficiency, measured with much care, determining the losses, when unloaded, by the aid of a standardised electric motor, has been found equal to 61 per cent. at a current of 25 amperes and 45 volts (one circuit only), and 71·6 per cent. at a current of 50 amperes and 45 volts (two circuits in parallel). The periodic curves of Fig. 11, and the characteristics of Fig. 14 relative to one and two circuits coupled, exhibit the properties of this machine, which differ little, as we see, from those of the

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The extinction of the arc takes place generally when the pressure at the terminals of the regulator becomes more than 50 volts. The characteristic does not differ much from an ellipse, as Fig. 13 shows. We may then apply with sufficient approximation, as Dr. Hopkinson proposes, the ordinary formula of alternate current (Joubert's formula).

$$I = \frac{E}{\sqrt{R^2 + \left(\frac{2\pi L}{T}\right)^2}}$$

But the self induction, L, which figures in this formula is not constant, in fact we deduce from the curve; knowing the internal resistance of the machine, $r = 0·12\omega$, the following values for the inductive resistance $\frac{2\pi L}{T}$:—

For $I = 25$ amperes $\frac{2\pi L}{T} = 1·13\omega$

„ $I = 50$ „ $\frac{2\pi L}{T} = 0·86$

„ $I = 78$ „ (short circuit) $\frac{2\pi L}{T} = 0·85$

The value of 0·86 corresponds to a self-induction $\frac{0·86}{2·60} = 0·0024$ henry for the complete machine.

* This figure is the apparent efficiency; it ought to be reduced by 5 per cent. to take into account the factor of mean power (0·95) applicable to the arc.

† A more exhaustive study (*Lumière Electrique*, vol. 46, p. 460) shows that with equal retardation the difference of load produced, and, consequently, the corrective action maintaining the synchronism are so much weaker as the normal current is greater compared with the current that the machine can supply on short circuit. Now, in the De Meritens machine the former reaches about two-thirds of the latter, a figure comparatively high. The suitability of these machines for coupling is therefore not great, and the synchronisation might be prevented without much difficulty; in fact, it seems to become impossible when the diameters of the pulleys are in the least degree different, or the belts not equally stretched, of which we have recently had an example at Cape Gris-nez. The complete electrical coupling of the machine with a half machine, practised during some time in order to obtain a current of 75 amperes, has given no very satisfactory result. It gave rise to well marked periodic oscillations, which led to its abandonment.

‡ One of the objections that might be raised against the employment of De Meritens magnetos is that their proper working depends upon the preservation of the magnetism of their magnets. We should be justified, in truth, in having some doubts on this point, seeing that the current of the armature produces a demagnetising effect, and that certain "Alliance" machines (Port Said Lighthouse) have been completely demagnetised. But, in point of fact, except in certain special cases in which a magnet had been recognised as inferior from the outset, no sensible loss of magnetism has been noticed during 10 years in the machines of French lighthouses.

De Meritens magnetos. We might then have found immediately in this machine a satisfactory solution of the problem, if it had not shown certain defects of some importance—viz., the extended form of the two machines together with difficulties of electric coupling arising from the small inertia of the turning parts, and above all, the excessive heating of the armature.

Self Exciting Alternator with Core.—We might remedy without difficulty the greater part of these defects, but it has been preferred to attempt, for comparison, another type of alternator with a core to the armature, which enables such self induction to be obtained as may be desired, and which, owing to the employment of thin iron sheets, may give a better efficiency.

The "L'Eclairage Electrique" Company has constructed a new machine answering to these requirements, after the plans of their engineer, M. Labour. This alternator, Figs. 17 and 17B, shows a model and form similar to those of the Rechniewsky dynamos of the multipolar type. But the armature, in the form of a toothed ring, carries a winding of a special kind; each coil is, as Fig. 18 shows, a kind of flat bobbin formed of concentric turns wound in a number of grooves. Thanks to this arrangement, which is quite new for alternators, and which produces an intimate proximity between the iron and the copper in each coil, we obtain a great economy in the exciting, at the same time as the strong reaction of the armature which is desired. The air gap showing no sensible variation, and the reaction of the armature coils taking place progressively, this machine produces no humming.

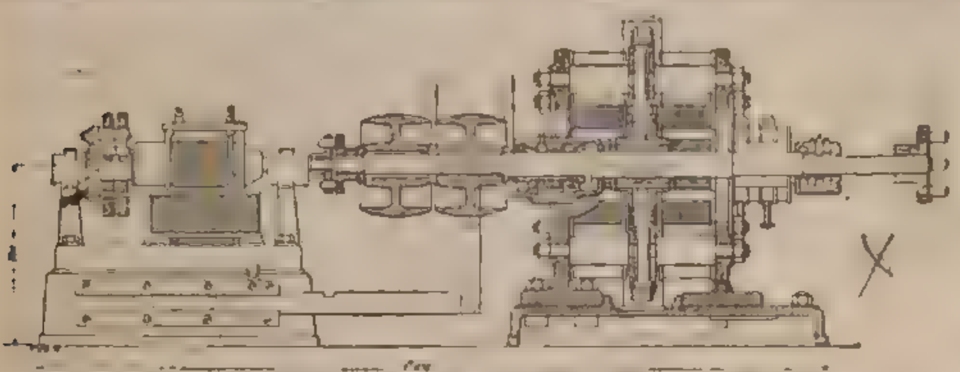


Fig. 16.

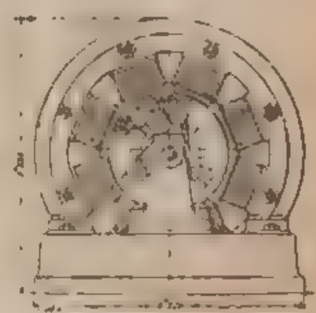


Fig. 17.

The electromagnets and the coils of the armature are still eight in number. The coils are coupled in two circuits, ending in three collecting rings. The principal data of construction are given below.

Data of Construction.—Speed, 800 revolutions. Frequency, 533 periods. Armature wire of 3·2mm. diameter, 36 turns per coil; resistance of one circuit, 0·164 ohms; 72 teeth—i.e., 9 per bobbin. Maximum induction, 7,280 C.G.S. Air gap, 5·5mm. Electromagnets, wire of 2·7mm. diameter, 260 turns per electro. Total resistance, 2·60 ohms. Exciting currents at the 25 ampere currents, I = 3·06 amperes and 3·77. Owing to the employment of the toothed ring, the expense for exciting is extraordinarily low (24 and 37 watts).

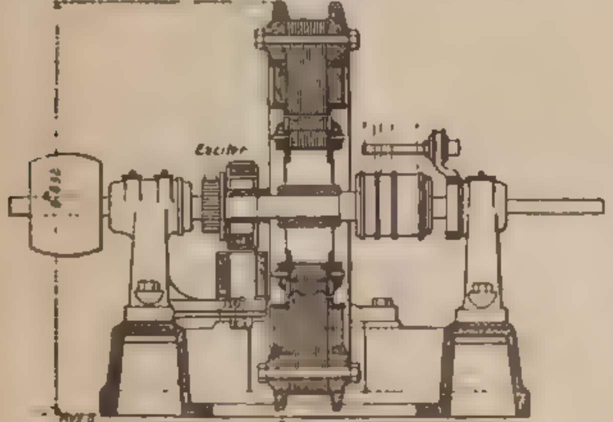


Fig. 17B.

The industrial efficiency, measured as in the case of the preceding machine, reaches the following figures, much superior to those of magnetos. One circuit alone, efficiency 72·2 per cent. Two circuits in parallel at 50 ampere current, 80·4 per cent.; 25 ampere current, obtained by the aid of a self induction coil, 74·5 per cent. The switchboard, Fig. 19, used for this last combination is remarkably simple, especially compared to that of Fig. 20. It was proposed chiefly to simplify the manner of exciting this alternator by the aid of a continuous current circuit, wrapped on the same armature and ending in a commutator placed at the opposite side to the alternate collector. But the reactions of the alternate current on the exciting current caused this arrangement to be abandoned after trial in favour of a small continuous current exciter placed immediately beside the armature, where the continuous current commutator was placed. The dimensions of the machine are not in this way increased. They are extremely small compared with the magnetos of De Meritens.

The periodic curves of Fig. 12 and the characteristics of Fig. 15 exhibit the properties of the machine, which, as we see, do not sensibly differ from those of the preceding machine. An excellent stability is obtained, the condition of maximum power is realised, and the intensity and short circuit is not much above the normal intensity. We may thus consider henceforward this machine as equivalent to the De Meritens magneto.

Comparison of Continuous and Alternate Currents.

This comparison, the elements for which have been furnished in the preceding chapters, should refer at once to the arc, the optical apparatus and the dynamos.

(1) *The Dynamos.*—The continuous current dynamos are satisfactory from the point of view of strength and safety. They show great economy in space and in cost compared to the De Meritens machines, but the steadiness of the arc has only been obtained at the cost of a loss of efficiency, the efficiency at the terminals of the lamp having been reduced to 0·58 or 0·65 at the 25 and 50 ampere currents.* On the contrary, the new alternators allow us to preserve the advantages of the De Meritens machines while costing a little more than the dynamos, and giving electrical efficiencies of 74 and 80 per cent. at the two currents considered. It is these machines, then, which appear at present likely to take the place of the De Meritens machines without any change in the remainder of the service.

But it is not to be forgotten that all the possible advantage obtainable from continuous current dynamos has not yet been obtained, and that by a suitable compounding we might probably realise a stability and efficiency superior to those hitherto obtained with these machines.

(2) *The Arc.*—In spite of the ingenious solenoid of MM. Sautter, Harlé and Cie., and the employment of the rheostat, the continuous current with the positive carbon below remains inferior in regularity to the alternate current arc. This may be seen from the following table, which sums up in a comparison the variations in illumination of the ray observed in the experiments of the central depôt.

Apparatus.	Current.	Relative variations of the luminous power.		
		With current of 25 amperes.	With current of 30 amperes.	With current of 100 amperes.
Feu éclair type, 1892 ..	alternate	Per cent. 30 to 36	Per cent. 40 to 50	Per cent. 50 to 70
Feu éclair type, 1892	continuous	1·42	1·65	1·87

This inferiority is especially important with feux-éclairs, in which the lamp turns with the apparatus, and where it is consequently necessary that the figure should be as symmetrical as possible in order that successive flashes may be of equal power. The arc with positive carbon uppermost would give in this respect more favourable results.

(3) *Apparatus.*—The present bi-focal apparatus is combined for the use of the alternate current. Experiments made at La Hève (*feu-éclair*) with an apparatus of 0·60m. diameter, in four panels, have given, with almost equal currents, luminous powers and efficiencies much superior with alternate currents to those obtained with continuous currents, as is shown by the following table.†

* It is just to observe, nevertheless, that at the lighthouse of La Hève, where the definitive experiments will take place, the steadying resistances may be suppressed in large measure owing to the resistance of the cables.

† We have not quoted in this table the figures of 1,800,000 becs, or 332 per watt, mentioned above, for the current of 98 amperes at 57 volts, because the 500,000 becs of increase were only gained by the excessive diminution of the negative carbon (18 mm. instead of 23), with which such a condition could not be maintained. It produces, also, too great irregularity, the power varying from 580,000 to 3,200,000 becs, while in the normal *régime* the power only varied from 1,300,000 to 3,130,000 becs.

heated also if it were connected to a source of a steady potential. In such a case electricity would be carried away from the button by the freely movable carriers or particles flying about, and the quantity of electricity thus carried away might be sufficient to bring the button to incandescence by its passage through the latter. But the bombardment could not be of great importance in such case. For this reason, it would require a comparatively very great supply of energy to the button to maintain it at incandescence with a steady potential. The higher the frequency of the electric impulses, the more economically can the button be maintained at incandescence. One of the chief reasons why this is so is, I believe, that with impulses of very high frequency there is less exchange of the freely movable carriers around the electrode, and this means that in the bulb the heated matter is better confined to the neighbourhood of the button. If a double bulb,

Incandescence or Phosphorescence of Rarefied Gas.

as illustrated in Fig. 30, be made, comprising a large globe, B, and a small one, b, each containing, as usual, a filament, f, mounted on platinum wire, w and w_1, it is found that if the filaments, $f\,f$, be exactly alike, it requires less energy to keep the filament in the globe, b, at a certain degree of incandescence than that in the large globe, B. This is due to the confinement of the movable particles around the button. In this case it is also ascertained that the filament in the small globe, b, is less deteriorated when maintained a certain length of time at incandescence. This is a necessary consequence of the fact that the gas in the small bulb becomes strongly heated, and therefore a very good conductor, and less work is then performed on the button, since the bombardment becomes less intense as the conductivity of the gas increases. In this construction of course the small bulb becomes very hot, and when it reaches an elevated temperature the convection and radiation on the outside increase. On another occasion I have shown bulbs in which this drawback was largely avoided. In these instances a very small bulb containing a refractory button was mounted in a large globe and the space between the walls of both was highly exhausted.

Luminosity of Gas at Ordinary Pressure.

The outer large globe remained comparatively cool in such constructions. When the large globe was on the pump, and the vacuum between the walls maintained permanent by the continuous action of the pump, the outer globe would remain quite cold, while the button in the small bulb was kept at incandescence. But when the seal was made, and the button in the small bulb maintained incandescent some length of time, the large globe, too, would become warmed. From this I conjecture that if vacuous space (as Prof. Dewar finds) cannot convey heat, it is so merely in virtue of our rapid motion through space, or, generally speaking, by the motion of the medium relatively to us, for a permanent condition could not be maintained without the medium being constantly renewed. A vacuum cannot, according to all evidence, be permanently maintained around a hot body.

In these constructions before mentioned the small bulb inside would, at least, in the first stages, prevent all bombardment against the outer large globe. It occurred to me then to ascertain how a metal sieve would behave in this respect, and several bulbs, as illustrated in Fig. 31, were prepared for this purpose. In a globe, b, was mounted a thin filament, f (or button), upon a platinum wire, w, passing through a glass stem and leading to the outside of the globe. The filament, f, was surrounded by a metal sieve, s. It was found in experiments with such bulbs that a sieve with wide meshes apparently did not in the slightest affect the bombardment against the globe, b. When the vacuum was high the shadow of the sieve was clearly projected against the globe and the latter would get hot in a short while. In some bulbs the sieve, s, was connected to a platinum wire sealed in the glass. When this wire was connected to the other terminal of the induction coil (the E.M.F. being kept low in this case), or to an insulated plate, the bombardment against the outer globe, b, was diminished. By taking a sieve with fine meshes the bombardment against the globe, b, was always diminished, but even then, if the exhaustion was carried very far, and when the potential of the transformer was very high, the globe, b, would be bombarded and heated quickly, though no shadow of the sieve was visible owing to the smallness of the meshes. But a glass tube or other continuous body mounted so as to surround the filament did entirely cut off the bombardment, and for a while the outer globe, b, would remain perfectly cold. Of course when the glass tube was sufficiently heated the bombardment against the outer globe, could be noted at once. The experiments with these bulbs seemed to show that the speeds of the projected molecules or particles must be considerable (though quite insignificant when compared with that of light), otherwise it would be difficult to understand how they could traverse a fine metal sieve without being affected, unless it were found that such small particles or atoms cannot be acted upon directly at measurable distances. In regard to the speed of the projected atoms, Lord Kelvin has recently estimated it at about one kilometre a second or thereabouts in an ordinary Crookes bulb. As the potentials obtainable with a disruptive discharge coil are much higher than with ordinary coils, the speeds must of course be much greater when the bulbs are lighted from such a coil. Assuming the speed to be as high as five kilometres and

Showing the Effect of Confining the Gas Around the Electrode.

Showing the Inefficiency of a Metal Screen.

uniform through the whole trajectory, as it should be in a very highly exhausted vessel, then if the alternate electrifications of the electrode would be of a frequency of 5,000,000, the greatest distance a particle could get away from the electrode would be one millimetre, and if it could be acted upon directly at that distance, the exchange of electrode matter or of the atoms would be very slow, and there would be practically no bombardment against the bulb. This, at least, should be so, if the action of an electrode upon the atoms of the residual gas would be such as upon electrified bodies which we can perceive. A hot body enclosed in an exhausted bulb produces always atomic bombardment, but a hot body has no definite rhythm, for its molecules perform vibrations of all kinds.

If a bulb containing a button or filament be exhausted as high as is possible with the greatest care and by the use of the best artifices, it is often observed that the discharge cannot at first break through, but after some time, probably in consequence of some changes within the bulb, the discharge finally passes through and the button is rendered incandescent. In fact, it appears that the higher the degree of exhaustion the easier is the incandescence produced. There seems to be no other causes to which the incandescence might be attributed in such case except to the bombardment or similar action of the residual gas, or of particles of matter in general. But if the bulb be exhausted with the greatest care, can these play an important part? Assume the vacuum in the bulb to be tolerably perfect, the great interest then centres in the question, Is the medium which pervades all space continuous or atomic? If atomic, then the heating of a conducting button or filament in an exhausted vessel might be due largely to ether bombardment, and then the heating of a conductor in general through which currents of high frequency or high potential are passed must be modified by the behaviour of such medium; then also the skin effect, the apparent increase of ohmic resistance, etc., admit partially, at least, of a different explanation.

It is certainly more in accordance with many phenomena observed with high frequency currents to hold that all space is pervaded with free atoms rather than to assume that it is devoid of these, and dark and cold, for so it must be if filled with a continuous medium, since in such there can be neither heat nor light. Is then energy transmitted by independent carriers or by the vibration of a continuous medium? This important question is

by no means as yet positively answered. But most of the effects which are here considered, especially the light effects, incandescence or phosphorescence, involve the presence of free atoms, and would be impossible without these.

In regard to the incandescence of a refractory button (or filament) in an exhausted receiver, which has been one of the subjects of this investigation, the chief experiences which may serve as a guide in constructing such bulbs may be summed up as follows: (1) The button should be as small as possible, spherical, of a smooth or polished surface, and of refractory material which withstands evaporation best. (2) The support of the button should be very thin and screened by an aluminium and mica sheet, as I have described on another occasion. (3) The exhaustion of the bulb should be as high as possible. (4) The frequency of the currents should be as high as practicable. (5) The currents should be of a harmonic rise and fall, without sudden interruptions. (6) The heat should be confined to the button by enclosing the same in a small bulb or otherwise. (7) The space between the walls of the small bulb and the outer globe should be highly exhausted.

Most of the considerations which apply to the incandescence of a solid just considered may likewise be applied to phosphorescence. Indeed, in an exhausted vessel the phosphorescence is, as a rule, primarily excited by the powerful beating of the electrode stream of atoms against the phosphorescent body. Even in many cases where there is no evidence of such a bombardment, I think that phosphorescence is excited by violent impacts of atoms which are not necessarily thrown off from the electrode, but are acted upon from the same inductively through the medium or through chains of other atoms. That mechanical shocks play an important part in exciting phosphorescence in a bulb may be seen from the following experiment. If a bulb constructed as that illustrated in Fig. 10 be taken, and exhausted with the greatest care so that the discharge cannot pass, the filament, *f*, acts by electrostatic induction upon the tube, *t*, and the latter is set in vibration. If the tube, *o*, be rather wide, about an inch or so, the filament may be so powerfully vibrated that whenever it hits the glass tube it excites phosphorescence. But the phosphorescence ceases when the filament comes to rest. The vibration can be arrested and again started by varying the frequency of the currents. Namely, the filament has its own period of vibration, and if the frequency of the currents is such that there is resonance, it is set easily vibrating, though the potential of the currents be small. I have often observed that the filament in the bulb is destroyed by such mechanical resonance. The filament vibrates, as a rule, so rapidly that it cannot be seen, and the experimenter may at first be mystified. When such an experiment as the one described is carefully performed, the potential of the currents need be extremely small, and for this reason I infer that the phosphorescence is then due to the mechanical shock of the filament against the glass, just as it is produced by striking a loaf of sugar with a knife. The mechanical shock produced by the projected atoms is easily noted when a bulb containing a button is grasped in the hand, and the current turned on suddenly. I believe that a bulb could be shattered by observing the conditions of resonance.

In the experiment before cited it is, of course, open to say that the glass tube, upon coming in contact with the filament, retains a charge of a certain sign upon the point of contact. If now the filament again touches the glass at the same point while it is oppositely charged, the charges equalise under evolution of light. But nothing of importance would be gained by such an explanation. It is unquestionable that the initial charges given to the atoms or to the glass play some part in exciting phosphorescence. So, for instance, if a phosphorescent bulb be first excited by a high frequency coil by connecting it to one of the terminals of the latter and the degree of luminosity noted, and then the bulb be highly charged from a Holtz machine by attaching it preferably to the positive terminal of the machine, it is found that when the bulb is again connected to the terminal of the high frequency coil, the phosphorescence is far more intense. On another occasion I have considered the possibility of some phosphorescent phenomena in bulbs being produced by the incandescence of an infinitesimal layer on the surface of the phosphorescent body. Certainly, the impacts of the atoms are powerful enough to produce intense incandescence by the collisions, since they bring quickly to a high temperature a body of considerable bulk. If any such effect exists, then the best appliance for producing phosphorescence in a bulb which we know so far is a disruptive discharge coil giving an enormous potential with but few fundamental discharges, say 25-30 per second, just enough to produce a continuous impression upon the eye. It is a fact that such a coil excites phosphorescence under most any condition and at all degrees of exhaustion, and I have observed effects which appear to be due to phosphorescence even at ordinary pressures of the atmosphere, when the potentials are extremely high. But if phosphorescent light is produced by the equalisation of charges of electrified atoms (whatever this may mean ultimately), then the higher the frequency of the impulses, or alternate electrifications, the more economical will be the light production. It is a long known and noteworthy fact that all the phosphorescent bodies are poor conductors of electricity and heat, and that all bodies cease to emit phosphorescent light when they are brought to a certain temperature. Conductors, on the contrary, do not possess this quality. There are but few exceptions to the rule. Carbon is one of them. Becquerel noted that carbon phosphoresces at a certain elevated temperature preceding the dark red. This phenomenon may be easily observed in bulbs provided with a rather large carbon electrode (say, a sphere of six millimetres diameter). If the current is turned on after a few seconds a snow white film covers the electrode, just before it gets dark red. Similar effects are noted with other conducting bodies, but many scientific men will probably not attribute them to true phosphorescence. Whether true incandescence has anything to do with phosphorescence excited by atomic impact or mechanical shocks still remains to be decided, but it is a fact that all conditions which tend to localise and increase the heating effect at the point of impact are almost invariably the most favourable for the production of phosphorescence. So, if the electrode be very small, which is equivalent to saying in general that the electric density is great, if the potential be high, and if the gas be highly rarefied, all of which things imply high speed of the projected atoms, or matter, and consequently violent impacts, the phosphorescence is very intense. If a bulb provided with a large and small electrode be attached to the terminal of an induction coil, the small electrode excites phosphorescence while the large one may not do so, because of the smaller electric density and hence smaller speed of the atoms. A bulb provided with a large electrode may be grasped with the hand while the electrode is connected to the terminal of the coil, and it may not phosphoresce; but if instead of grasping the bulb with the hand, the same be touched with a pointed wire, the phosphorescence at once spreads through the bulb, because of the great density at the point of contact. With low frequencies it seems that gases of great atomic weight excite more intense phosphorescence than those of smaller weight, as, for instance, hydrogen. With high frequencies the observations are not sufficiently reliable to draw a conclusion. Oxygen, as is well known, produces exceptionally strong effects, which may be in part due to chemical action. A bulb with hydrogen residue seems to be most easily excited. Electrodes which are most easily deteriorated produce more intense phosphorescence in bulbs, but the condition is not permanent because of the impairing of the vacuum and the deposition of the electrode matter upon the phosphorescent surfaces. Some liquids, as oils, for instance, produce magnificent effects of phosphorescence (or fluorescence?), but they last only a few seconds; so if a bulb have a trace of oil on the walls, and the current is turned on, the phosphorescence only persists for a few moments until the oil is carried away. Of all bodies so far tried, sulphide of zinc seems to be the most susceptible to phosphorescence. Some samples obtained through the kindness of Prof. Henry, in Paris, were employed in many of these bulbs. One of the defects of this sulphide is that it loses its quality of emitting light when brought to a temperature which is by no means high. It can therefore be used only for feeble intensities. An observation which might deserve notice is that when violently bombarded from an aluminium electrode it assumes a black colour, but, singularly enough, it returns to the original condition when it cools down.

The most important fact arrived at in pursuing investigations in this direction is that in all cases it is necessary, in order to excite phosphorescence with a minimum amount of energy, to observe certain conditions. Namely, there is always, no matter what the frequency of the currents, degree of exhaustion and character of the bodies in the bulb, a certain potential (assuming the bulb excited from one terminal) or potential difference (assuming the bulb to be excited with both terminals) which produces the most economical result. If the potential be increased, considerable energy may be wasted without producing any more light, and if it be diminished, then again the light production is not as economical. The exact condition under which the best result is obtained seems to depend on many things of a different nature, and it is yet to be investigated by other experimenters; but it will certainly have to be observed when such phosphorescent bulbs are operated if the best results are to be attained.

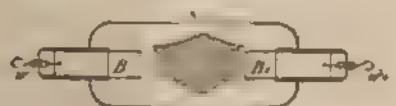
Coming now to the most interesting of these phenomena, the incandescence or phosphorescence of gases, at low pressures or at the ordinary pressure of the atmosphere, we must seek the explanation of these phenomena in the same primary causes, that is, in shocks or impacts of the atoms. Just as molecules or atoms beating upon a solid body excite phosphorescence in the same or render it incandescent, so when colliding among themselves they produce similar phenomena; but this is a very insufficient explanation, and concerns only the crude mechanism. Light is produced by vibrations which go on at a rate almost inconceivable. If we compute from the energy contained in the form of known radiations in a definite space the force which is necessary to set up such rapid vibrations, we find that though the density of the ether be incomparably smaller than that of any body we know—even hydrogen—the force is something surpassing comprehension. What is this force, which in mechanical measure may amount to thousands of tons per square inch? It is electrostatic force in the light of modern views. It is impossible to conceive how a body of measurable dimensions could be charged to so high a potential that the force would be sufficient to produce these vibrations. Long before any such charge could be imparted to the body it would be shattered into atoms. The sun emits light and heat, and so does an ordinary flame or incandescent filament, but in neither of these can the force be accounted for if it be assumed that it is associated with the body as a whole. Only in one way may we account for it, namely, by identifying it with the atom. An atom is so small, that if it be charged by coming in contact with an electrified body and the charge be assumed to follow the same law as in the case of bodies of measurable dimensions, it must retain a quantity of electricity which is fully capable of accounting for these forces and tremendous rates of vibration. But the atom behaves singularly in this respect—it always takes the same "charge."

It is very likely that resonant vibration plays a most important part in all manifestations of energy in nature. Throughout space all matter is vibrating, and all rates of vibration are represented, from the lowest musical note to the highest pitch of the chemical

rays, hence an atom, or complex of atoms, no matter what its period, must find a vibration with which it is in resonance. When we consider the enormous rapidity of the light vibrations, we realise the impossibility of producing such vibrations directly with any apparatus of measurable dimensions, and we are driven to the only possible means of attaining the object of setting up waves of light by electrical means and economically—that is, to affect the molecules or atoms of a gas, to cause them to collide and vibrate. We then must ask ourselves—How can free molecules or atoms be affected?

It is a fact that they can be affected by electrostatic force, as is apparent in many of these experiments. By varying the electrostatic force we can agitate the atoms, and cause them to collide under evolution of heat and light. It is not demonstrated beyond doubt that we can affect them otherwise. If a luminous discharge is produced in a closed exhausted tube, do the atoms arrange themselves in obedience to any other but to electrostatic force acting in straight lines from atom to atom? Only recently I investigated the mutual action between two circuits with extreme rates of vibration. When a battery of a few jars (*c c*,

Electrostatic Action Between Primary and Secondary, with Extremely High Frequencies.



Carbon Deposit in Tube in a Magnetic Field

Fig. 32) is discharged through a primary P, of low resistance (the connections being as illustrated in Figs. 19*a*, 19*b*, 19*c*), and the frequency of vibration be many million, there are great differences of potential between points on the primary not more than a few inches apart. These differences may be 10,000 volts per inch, if not more, taking the maximum value of the E.M.F. The secondary, *s*, is therefore acted upon by electrostatic induction, which is in such extreme cases of much greater importance than the electro-dynamic. To such sudden impulses the primary, as well as the secondary, are poor conductors, and therefore great differences of potential may be produced by electrostatic induction between adjacent points on the secondary. Then sparks may jump between the wires and streamers become visible in the dark

vibrate as a whole. I am convinced that no discharge through a gas can vibrate. The atoms of a gas behave very curiously in respect to sudden electric impulses. The gas does not seem to possess any appreciable inertia to such impulses, for it is a fact that the higher the frequency of the impulses, with the greater freedom does the discharge pass through the gas. If the gas possesses no inertia then it cannot vibrate, for some inertia is necessary for the free vibration. I conclude from this that if a lightning discharge occurs between two clouds, there can be no oscillation, such as would be expected, considering the capacity of the clouds. But if the lightning discharge strike the earth, there is always vibration—in the earth, but not in the cloud. In a gas discharge each atom vibrates at its own rate, but there is no vibration of the conducting gaseous mass as a whole. This is an important consideration in the great problem of producing light economically, for it teaches us that to reach this result we must use impulses of very high frequency and necessarily also of high potential. It is a fact that oxygen produces a more intense light in a tube. Is it because oxygen atoms possess some inertia and the vibration does not die out instantly? But then nitrogen should be as good, and chlorine and vapours of many other bodies much better than oxygen, unless the magnetic properties of the latter enter prominently into play. Or, is the process in the tube of an electrolytic nature? Many observations certainly speak for it, the most important being that matter is always carried away from the electrodes and the vacuum in a bulb cannot be permanently maintained. If such process takes place in reality, then, again, must we take refuge to high frequencies, for with such electrolytic action should be reduced to a minimum, if not rendered entirely impossible. It is an undeniable fact that with very high frequencies, provided the impulses be of a harmonic nature, like those obtained from an alternator, there is less deterioration and the vacua are more permanent. With disruptive discharge coils there are sudden rises of potential and the vacua are more quickly impaired, for the electrodes are deteriorated in a very short time. It was observed in some large tubes, which were provided with heavy carbon blocks, B B_1, connected to platinum wires, *w* w_1 (as illustrated in Fig. 33), and which were employed in experiments with the disruptive discharge instead of the ordinary air gap, that the carbon particles under the action of the powerful magnetic field in which the tube was placed, were deposited in regular fine lines in the middle of the tube as illustrated. These lines were attributed to the deflection or distortion of the discharge by the magnetic field, but why the deposit occurred principally where the field was most intense did not appear quite clear. A fact of interest, likewise noted, was that the presence of a strong magnetic field increases the deterioration of the electrodes, probably by reason of the rapid interruptions it produces, whereby there is actually a higher E.M.F. maintained between the electrodes.

Spoke Wheel

Alternate Motor Winding.

Ring Winding

Drum Winding.

Some of the Designs Produced by Intermittent Discharges.

if the light of the discharge through the spark gap, *d d*, be carefully excluded. If now we substitute a closed vacuum tube for the metallic secondary, *s*, the differences of potential produced in the tube by electrostatic induction from the primary are fully sufficient to excite portions of it; but as the points of certain differences of potential on the primary are not fixed, but are generally constantly changing in position, a luminous band is produced in the tube, apparently not touching the glass, as it should if the points of maximum and minimum differences of potential were fixed on the primary. I do not exclude the possibility of such a tube being excited only by electro-dynamic induction, for very able physicists hold this view; but, in my opinion, there is as yet no positive proof given that atoms of a gas in a closed tube may arrange themselves in chains under the action of an electromotive impulse produced by electro-dynamic induction in the tube. I have been unable so far to produce striæ in a tube, however long, and at whatever degree of exhaustion—that is, striæ at right angles to the supposed direction of the discharge or the axis of the tube; but I have distinctly observed in a large bulb, in which a wide luminous band was produced by passing a discharge of a battery through a wire surrounding the bulb, a circle of feeble luminosity between two luminous bands, one of which was more intense than the other. Furthermore, with my present experience I do not think that such a gas discharge in a closed tube can vibrate—that is,

Much would remain to be said about the luminous effects produced in gases at low or ordinary pressures. With the present experiences before us we cannot say that the essential nature of these charming phenomena is sufficiently known. But investigations in this direction are being pushed with exceptional ardour. Every line of scientific pursuit has its fascinations, but electrical investigation appears to possess a peculiar attraction, for there is no experiment or observation of any kind in the domain of this wonderful science which would not forcibly appeal to us. Yet to me it seems, that of all the many marvellous things we observe, a vacuum tube, excited by an electric impulse from a distant source, bursting forth out of the darkness and illuminating the room with its beautiful light, is as lovely a phenomenon as can greet our eyes. More interesting still it appears when, reducing the fundamental discharges across the gap to a very small number and waving the tube about, we produce all kinds of designs in luminous lines. So, by way of amusement, I take a straight long tube, or a square one, or a square attached to a straight tube, and by whirling them about in the hand I imitate the spokes of a wheel, a Gramme winding, a drum winding, an alternate current motor winding, etc., Fig. 34. Viewed from a distance, the effect is weak and much of its beauty is lost; but being near, or holding the tube in the hand, one cannot resist its charm.

In presenting these insignificant results I have not attempted to arrange and co-ordinate them as would be proper in a strictly

scientific investigation in which every succeeding result should be a logical sequence of the preceding, so that it might be guessed in advance by the careful reader or attentive listener. I have preferred to concentrate my energies chiefly upon advancing novel facts or ideas which might serve as suggestions to others, and this may serve as an excuse for the lack of harmony. The explanations of the phenomena have been given in good faith and in the spirit of a student prepared to find that they admit of a better interpretation. There can be no great harm in a student taking an erroneous view, but when great minds err the world must dearly pay for their mistakes.

STAFFORD ELECTRIC LIGHTING.

REPORT BY DR. JOHN HOPKINSON, M.A., F.R.S., M.I.C.E., ETC.

I have carefully considered the conditions of the town of Stafford in regard to electric lighting, and have visited the town for the purpose of seeing the site upon which it appears to be best to erect the machinery, and the character of the demand for light in the town.

The town of Stafford presents both favourable and unfavourable conditions in regard to electric lighting. Coal is cheap, water for condensation is accessible, and it would be easy for the Corporation to combine in a measure their electric light staff and the staff employed in the production of gas; these conditions all tend to economy of production. On the other hand, the demand for electric light in the town is not likely to be very large, and there will be many consumers whose demand for a supply will last for a short time only, whose account will therefore be small, but for whom it will be necessary to incur considerable expenditure for plant.

The first point to be decided is the site upon which the generating machinery is to be placed. In this respect you are fortunate, inasmuch as you have an excellent site at the gasworks which is not likely to be required for the production of gas. This site presents the advantage that, if steam be used, the boilers can be utilised for the purpose of the gasworks when they are not required for the production of electric light. From this will result a considerable economy of coal and wages. The site, too, is in proximity to the district where at first the principal demand may be expected. I am therefore of opinion that there can be no doubt whatever that the gasworks site is the right site for you to adopt.

The site for the generating plant having been decided upon, the next question is, what is the right system of supply to adopt? The whole of the lighting which you will have to do at first is comprised within a distance of about 700 yards from the generating station. It is now well recognised by all electric light engineers that when the district to be lighted is so near to the generating station, the proper system to adopt is that with continuous currents at low pressure. The continuous current has the great advantage that with it accumulators may be used. These are continually becoming cheaper, and even at their present price they are of great service in small stations, such as yours will be, in enabling the machinery to be stopped during the greater part of the 24 hours, so economising the wages of the attendants, who otherwise would have to be present for the purpose of supplying a very few lights. They have also the advantage that they enable you to increase to a material extent the maximum output of the station, inasmuch as you are able to add the output of the accumulators to the output of the machinery. The continuous current has the further advantage that it is more readily applied to the supply of mechanical power. I should therefore advise you to adopt the continuous current, with the system of conductors known as the three-wire system, which enables you to materially increase the pressure at which you work, and therefore to diminish the size and cost of your conductors. I should also advise you to make use of accumulators. If at a future time a demand for electricity arises at a greater distance from the station, this would be met by putting down a battery in the neighbourhood of the demand, and charging the battery from the station directly, if the distance did not exceed a mile, by means of a transformer if it was more considerable. One question still remains—as to the motive power to be used. It has been suggested that gas-engines should be adopted. I have not the least doubt that a perfectly satisfactory result could be attained with gas engines. I should, however, prefer steam for two reasons—firstly, if gas-engines be used it is necessary to increase the number of accumulators employed, in order to secure that steadiness of light which is essential; accumulators, of course, are costly instruments, and it is not desirable to increase their numbers beyond what is really necessary. Secondly, on anything but a small scale steam is cheaper than gas.

In laying out a plant for an electric light station it is of the greatest importance to so arrange that in the first instance no more machinery is laid down than there is reasonable certainty will be required within a very short time, and on the other hand, that as the demand increases, extensions can be made without undoing work already done. You are under obligation to supply light within an area indicated in your provisional order, and with this area I should advise you to begin, putting down distributing conductors from your generating station along Gaolgate street and Greengate street, to the end of Bridge street, and laying a feeder from the generating station to the Market square, which is the point at which your greatest demand is likely to be found. From this system of distributors you will lay service conductors to the various consumers as may be required. The cost of these conductors will be seen from the annexed schedule. The amount of light which will be required in this area is of course, necessarily a matter of speculation: it is impossible to say how many of the shops will take it, as this may be governed partly even by fashion. If one shopkeeper chooses to take it, his neighbours will probably follow his example. I think, however, that you cannot do less than begin with three engines of about 100 i.h.p. each, each driving a dynamo machine working at about 240 volts. Each of these machines would be capable of giving a maximum of about 60 units per hour—that is, of supplying 900 16-c.p. lights, or a little more. Two of these machines would be at work at one time, the other being spare. In connection with these machines I would provide an accumulator capable of giving 46 units for three hours, or, if absolutely necessary, 88 units for one hour, bringing up the total normal supply to 166 units. In the schedule appended to this report will be found an estimate of the cost of this plant, from which it appears that the expenditure which I consider it is absolutely necessary for the Corporation to incur is £12,000. In this estimate it will be observed that there is an adequate allowance for contingencies, and that meters are not included. As, however, I think that further extensions will be speedily required, I should advise you to go to the Local Government Board for permission to borrow a larger sum though I would not advise you to order more plant in the first instance. An estimate should be prepared, conceived upon a somewhat wider basis, to justify the larger borrowing powers. This larger estimate I have no doubt would be soon justified by the actual execution of work, but there is no necessity for incurring the expenditure until the demand actually makes it necessary.

The present estimate, then, is for machinery, mains, and everything necessary for a supply of 166 kilowatts (units per hour), or for lighting 2,500 16-c.p. lamps at one time. This would probably permit twice as many lamps to be wired, as it is not likely that more than that proportion would be required at one time. An additional 120 kilowatts could be added by a capital outlay of about £5,500, and further additions in proportion.

In the second schedule is given the estimate of the expenses chargeable to revenue. The coal account is small, but it must be remembered that the great expense of coal in electric lighting is due to the short hours during which steam is used; in your case these hours will be extended by other uses for the steam. The repairs are estimated for an average of many years; they would at first be much less.

An estimate of annual receipts is difficult, and must of necessity be something of a guess. I will assume, however, that 100,000 units are paid for per annum—that is to say, that the output of the station is used for 600 hours in the year, a figure which I should hope would be exceeded. If that were so, the electric light would pay its way at an average charge of 4½d. per unit. At this price, electric light would cost the consumer about 30 per cent. more than gas.

An inspection of my estimate of annual expenses at once shows that the expense of supplying customers for many hours is not much greater than that of supplying them for very few. The profitable consumers are those whose demand is long. In other towns I have endeavoured to meet this by a method of charge partly by meter and partly by the maximum current which the consumer may take. When the time comes, I should advise you to adopt a similar system.

The conclusions at which I arrive are: That the electric lighting will certainly pay in Stafford, but that the profits will not be large as the business will be small; that the necessary outlay will be £12,000, but that the Local Government Board should be asked to sanction a loan of £20,000; that the system should be the three-wire direct current system, supplied by steam engines and a small battery of accumulators.

SCHEDULE I.

Two boilers, with mountings and injectors; Two economisers, each of 72 pipes; Steam and water pipes	£1,665
Three condensing engines, each of 100 i.h.p.; Three ejector condensers; Two steam-pumps for supplying water to condensers; Water pipes for pumps and condensers; Three belts	1,920
Three dynamos	990
Conductors: Distributors from engine house to junction of Greengate and Mill Bank; Feeders from engine house to Market square; 100 house connections	2,420
Accumulators	1,190
Switchboards and instruments	300
Buildings, including overhead traveller	2,000
	10,485
Contingencies, engineering expense, 15 per cent.	1,572
	£12,057

SCHEDULE II.

Interest and sinking fund, at 6 per cent.	£720
Coal, at 6lb. per unit	90
Oil, waste, and petty stores	20
Wages for running, exclusive of wages for repair	350
Repairs and maintenance, at 5 per cent.	600
	£1,780

LEGAL INTELLIGENCE.

HALL v. VAUGHAN

A case of considerable interest to electrical engineers came on for hearing at the Liverpool Assizes before Mr Justice Kennedy and a special jury on Thursday, August 3.

The plaintiffs, Messrs. A. Hall and Co., electrical engineers and contractors, of 1 and 11, South John street, Liverpool, sued Mr. John Vaughan, of Nannau, Dolgelly, to recover £665 damages for breach of contract. The circumstances appear to have been as follows. Early in December last plaintiffs supplied an estimate for lighting defendant's mansion, which was accepted; the plaintiffs immediately preparing to execute the work and contracting with other manufacturers for the turbine and generating plant. After a few weeks the defendant, without consulting Messrs. Hall, appointed as his consulting engineer a gentleman who happened to be a local contractor and competitor of the plaintiffs, and they immediately advised the defendant that having already undertaken the work and accepted all responsibility, they could not recognise the authority of any engineer to interfere with their arrangements, especially as they asked no payment until the whole was satisfactorily completed, and were willing that the defendant should have the installation examined and tested by any recognised consulting engineer before accepting same. The defendant, however, would not allow the plaintiffs to commence the erection of any part of the installation, and after delaying for considerable time, during which he sent enquiries for various particulars of the work to submit to his engineer, he finally refused to allow plaintiffs to carry out their contract, stating it would not be satisfactory. The plaintiffs therefore sued for damages, and when the case came on in court, the defendant's counsel, evidently appreciating plaintiffs' position, offered to compromise by paying £150 costs, and withdrawing any imputation upon plaintiffs' ability to carry out the work. This was accepted. The installation consisted of 120 16 c.p. incandescent lamps to be erected in the Hall, the generating plant being placed near a stream three-quarter mile distant from the Hall, and it included a special Victor turbine. As there was at all times an abundance of water and the attendant was to live in rooms adjoining the one containing the generating machines, the plaintiffs offered to carry out the work without accumulators, and their contract did not include that. It was evident there would be a considerable loss in the mains, and that means for regulating the E.M.F. at their distant end must be provided. This was stated could not be satisfactorily done. In their estimate plaintiffs only specified compound machines, and in answer to the enquiries afterwards sent them they stated they expected to use a $\frac{19}{14}$ main, which would have resistance of about ·68 ohm. The lamp voltage was to be 110, and therefore with such a cable the maximum loss during a night would have been about 20 volts, or 15 per cent., that is, with 50 lights on, which is probably more than required on all ordinary occasions; but if every lamp in the house had been switched on, there would have been a loss of 48 volts, or about 31 per cent. of the dynamo E.M.F. Plaintiffs had not bound themselves to that size of cable, but stated it as the smallest they might use. Their arrangements consisted of a large machine capable of supplying all the lamps to be used during the hours of heavy load, and a small machine capable of driving a little less than half the lamps to be used during the night and hours of light load. Both machines would have been compound wound to raise the E.M.F. as the current increased, so as to compensate for the loss in the cables and maintain a constant E.M.F. at the distant end. That is frequently done with colliery lighting machines, and in other similar places where there is a single pair of mains with the load at the far end. It will be seen that if a cable as small as stated were used the large machine would have to "compound up" nearly 45 per cent. of its minimum E.M.F. (110 volts) when driving every lamp in the house, and it is possible that a machine wound to do this might give an unstable E.M.F., the tendency being always for its E.M.F. to drop too low, if it should be kept running when there was a very light load. This, plaintiffs stated, could be obviated by the use of a Willans governor; it being arranged to operate a switch inserting resistance in the dynamo shunt or the main circuit, thereby correcting and assisting the dynamo regulation as well as increasing its range, the machine being then easily wound within its limits of stability. Plaintiffs stated that they intended to fix an automatic cut-out at the house, so that even if any accident were possible there could be no danger of an injurious E.M.F. reaching the lamps. The cut-out would have, of course, been shunt wound, and adjusted to work at about 115 volts. The small machine had only to compound for two-fifths of the total load, and would in any case be easily made to give a stable E.M.F. and even regulation throughout its range. It will be noticed that the possible failing of the E.M.F. of large machine at light load, even with no governor, would not be any trouble, as the smaller machine only was intended for use during that time. The plaintiffs had also obtained definite offers from Messrs. Crompton and Co., Wilson Hartnell, Esq., of Leeds, and Messrs. A. M. Walker and Co., of Liverpool, all of whom were prepared to supply dynamo machines compound wound for the maximum loss stated, and to guarantee their satisfactorily regulating over the whole range, using a small coupled separate exciter for the shunt and no governor at all. Another method, plaintiffs state, they could have used for the larger machine is that of placing in the circuit a small series wound step-up dynamo to compensate for the loss, it being in series with the large machine, which could then have been plain shunt wound. Their case was simply that they had the contract, and were prepared to prove that they could have carried it out satisfactorily. Although they obtained practically the same terms they had offered before taking proceedings, they state that they much regret having been so interfered with as to obliged them to do so. There being so few places in this country where there is such an excess over the required water power at so convenient a distance, the installation would certainly have been interesting.

On behalf of the plaintiffs the following gentlemen appeared in court to give evidence: Mr. C. T. B. Brain (to whom plaintiffs had previously referred the case), and Messrs. W. H. Pott (representing Messrs. Crompton and Co.), Wilson Hartnell (of Leeds), and A. M. Walker (of Messrs. Walker and Co., Liverpool). Besides Mr. Lester Taylor, the gentleman whom defendant consulted, he had engaged Messrs. A. B. Holmes, F. G. Bailey, T. L. Miller, and W. J. Boult.

COMPANIES' MEETINGS.

LIVERPOOL OVERHEAD RAILWAY COMPANY.

The tenth half-yearly general meeting of the proprietors of this Company was held on Tuesday, at Liverpool, under the presidency of Sir Wm. B. Forwood. The report and statement of accounts were taken as read.

The **Chairman,** in moving their adoption, said: It affords your Directors very great satisfaction to meet you on this the first annual meeting after the completion of our overhead railway. This feeling of satisfaction is very much increased by the fact that the railway, both in its construction and in its electrical equipment, has been most successfully carried out. Very rarely indeed has an undertaking of such magnitude, involving so many considerations of the highest scientific importance, been so successfully inaugurated. From the first week after the railway was opened for public traffic we have maintained a regular and reliable quick service of trains, and to-day, although we are running a five minutes service, 94 per cent. of our trains are on time, and of the remaining 6 per cent. 3 per cent. are irregular only to the extent of a few seconds. Yesterday we ran a 3½ minutes' service without a hitch. For this excellent result we are indebted to the skill of our engineers, Sir Douglas Fox and Mr. Greathead, whom I am glad to see here to-day; last, though by no means least, the attention and care of our general manager and engineer, Mr. Cottrell. Your Directors only modestly claim credit for having insisted upon having first-class work both in the construction and equipment of the railway, and also in having everything thoroughly and carefully tested before opening the line for traffic. The accounts presented to you to-day embrace a period of rather more than 16 weeks; we carried during that period 1,370,742 passengers, or at the rate of 4,300,000 per annum. It is estimated that the penny omnibuses at present running in competition with the railway are carrying at the rate of 2,000,000 passengers per annum, thus making the traffic already developed along the line of docks more than 6,000,000 passengers per annum; and this during a time of great commercial depression, when the shipping trade of the port has been paralysed. This depression has affected the railway in a curious way. Usually the roadway fringing the docks is so blocked with carts and lurries conveying merchandise as to make quick vehicular traffic impossible. At present the goods traffic is so light that the omnibuses have been able to make very fair running time. This, coupled with the extraordinarily fine weather, has no doubt given them a larger proportion of the passengers than will, with ordinary conditions, fall to them. We are every day developing new sources of traffic. A ride upon the electric overhead railway has become an important item in the programme of every well-conducted excursion, and although our present northern terminus is nearly a mile away from the Seaforth shore, we carry large numbers destined for Seaforth. This induces your Directors to expect a large increase of traffic on completion of the northern extension. While we are thus engaged in endeavouring to increase the number of our travellers we are not unmindful of making such economies in our working expenses as may be practicable, having due regard to the efficiency of the service. Electrical traction, combined with automatic electric signals and lighting, should make a very cheaply worked line; and we believe when we take the electrical generating station into our own hands we shall effect a considerable saving. But we have, however, never regretted having placed this part of our system in the hands of the Electric Construction Corporation to work for us until it had been thoroughly tested. You will notice that the result of our 16 weeks' working has been that, after paying all expenses, rates, and taxes, and general charges, there is a balance to the credit of net revenue account of £5,361 15s.; deducting from this interest on debentures and the dividend due on our preference capital, we are left with a balance of £3,293 9s. This is equal to about 2½ per cent. on our ordinary capital for the time we have been at work. Your Directors recommend that the balance be carried forward. The amount of share capital issued is £470,000, and of debenture stock £125,000. This, your Directors estimated, would complete the railway, including the northern expansion to Seaforth, but we find we have to provide about £11,000 to settle the contractor's bill of extras, and a further amount for new stations. We also consider we ought to have a sum in hand as working capital to provide for these items. We, to-day at a special meeting, ask you for power to issue the remainder of the preference capital. We shall, of course, only issue such an amount as may be necessary; we are unable at present to define the

amount, as a good deal depends upon the settlement of our accounts with the Dock Board. These accounts are now in course of adjustment. The northern extension is being proceeded with and should be completed by the end of the year. In conclusion, I have only to repeat what I have said before, that in the overhead railway we have a very valuable property with a sure, and I think rapidly progressive future. There have been many in Liverpool who have been sceptical as to the extent of our traffic, and the estimate we put forward in our prospectus of 5,000,000 passengers per annum was deemed extravagant. We have only been running for four months, yet we see a total traffic developed of over 8,000,000 per annum. It is the old, old story: give rapid, frequent, and cheap means of travel through a populous place, and you cannot fail to create an unlooked for and unexpected amount of travel. These conditions exist upon our railway, and I feel certain you will not be disappointed. No one who has witnessed the marvellous development of local travel which has followed the opening of the overhead railway in New York can doubt that a similar development will take place on the Liverpool Overhead Railway. We are not so fully supported by our merchants and shipowners as we had a right to expect, for the railway was mainly constructed for their convenience and to enable them to economise in their working expenses. Cotton porters, ship people, and passengers still largely use the buses, though the loss of time in doing so is very considerable. I think we may fairly ask the mercantile public to take a little trouble to see that their work-people make use of the railway. We have also introduced cheap workmen's return tickets. Return tickets for 2d. are now issued up to 8 a.m., which are available for return during any hour of the day. We shall consider further concessions in this direction. We see our way to a considerable increase of our excursion traffic next year, and we are every day drawing more and more passengers from those parts of Bootle and Toxteth Park in proximity to the railway. To give you an idea of the earning capacity of the railway—in consequence of the fire at the north end, we yesterday carried 47,456 passengers, our earnings for the day making £413 14s. 3d. The Chairman concluded by moving the adoption of the report and the statement of accounts.

Mr. R. Hobson seconded the motion, which was carried.

On the motion of the **Chairman**, seconded by **Mr. R. Hobson**, a dividend of 5 per cent. per annum upon the preference shares of the Company was declared.

This concluded the business of the ordinary meeting, which then resolved itself into a special meeting.

The **Chairman** said the object had already been explained to them, and he simply moved "That the Directors be and they are hereby authorised to issue 4,500 preference shares of £10 each (being the unissued portion of the 12,000 preference shares of £10 each bearing interest at the rate of £5 per cent. per annum, created by the Company on the 10th day of January, 1893), in such amounts and manner, at such times and on such terms, as they may think fit."

Mr. Hobson seconded, and the resolution was carried unanimously.

Mr. Stevenson, a shareholder, enquired when it was intended to extend the railway southward.

The **Chairman** said they had parliamentary powers to carry the line southward so as to effect a junction with the Cheshire Lines Railway, and if they exercised these powers they would tap a large traffic. They had pledged themselves to the shareholders that they would obtain their sanction before proceeding with the extension, and that pledge they would carry out. At present the Directors thought that it would be better for them to develop the present line before fully undertaking that extension.

Another **Shareholder** asked if it was the intention of the Directors to allot the new issue of preference stock among the ordinary shareholders.

The **Chairman** said the subject would be carefully considered by the Board, and he hoped that the ordinary shareholders would obtain the bulk of the new stock.

A vote of thanks to the Chairman and Directors brought the meeting to a close.

COMPANIES' REPORTS.

BIRMINGHAM CENTRAL TRAMWAYS COMPANY, LIMITED.

Directors: Joseph Ebbsmith, Esq. (chairman), M. J. Smith, Esq., William Neale, Esq., W. J. Carruthers-Wain, Esq., A.I.C.E., managing director.

Report of the Directors to be submitted to the shareholders at the twelfth ordinary general meeting, to be held at the Queen's Hotel, Stephenson place, Birmingham, on Wednesday, August 16, 1893, at 12.30 p.m.

Working Accounts.—Having regard to the malignant and unfounded statements which have been made concerning the affairs of this Company, the Directors trust that every shareholder will give his especial attention to the accounts now presented. The record is one of traffic fully sustained, with a decrease of working expenses and an increase of working profits to the extent shown in the comparative statement.

Revenue Account.—The revenue account shows a balance of £24,216 8s. 1d., to which has to be added the sum of £13,921 18s. 8d. brought forward from last year's accounts, making together £38,138, 6s. 9d.

Appropriation of Profits.—Your Directors recommend (1) that the sum of £20,000 be placed to reserve account against depreciation;

WORKING ACCOUNTS.—COMPARATIVE STATEMENT.

Year ending.	Miles run.	Passengers carried.	Traffic receipts, etc.	Working expenses.	Working profits.
June			£ s. d.	£ s. d.	£ s. d.
30, 1892	2 657,145	25 718 282	152 238 15 2	115,210 13 5	37,028 1 9
30, 1893	2,655,802	26,277,080	154,684 5 8	111,230 4 10	43,454 0 10

(2) that the payment of the dividend upon the 5 per cent. guaranteed shares, amounting to £5,000, be confirmed; (3) that a dividend of 2½ per cent. for the year ending June 30, 1893, be declared and paid upon the ordinary shares of the Company, amounting to £9,700; and (4) that the balance of revenue account, amounting to £3,438. 6s. 9d., be carried forward.

Balance Sheet.—The shareholders will be gratified to observe how completely the audited accounts sustain the reassuring statement made by the chairman of the Board in his circular letter of June 12 in this year. The balance of £9 302. 18s. 4d. due to the bankers on June 30, 1892, has been repaid, and on June 30, 1893, the bankers held the sum of £8,623. 9s. 5d. to the credit of the Company. This result evidences the ignorance, if nothing worse, of those alarmists who wilfully excluded profit-earning power from the resources of the Company. Particular attention is directed to the auditors' certificate. It will be recollected that Mr. Mantle, in his circular of June 2 in this year, stated that the debenture issue could not be increased, and that the reserve fund was non-existent. It will be seen from the auditors' special certificate that the Company have debentures to the amount of £18,000 available for issue, if and when thought advisable; and that the reserve fund is invested in the most legitimate manner in the development of the resources of the Company.

Directors.—Having regard to the special character of the present meeting, the whole of the present ordinary Directors retire; and, being eligible, offer themselves for re-election. They have also the pleasure of stating that Messrs. B. J. Round and J. Booth, both well known citizens of Birmingham and substantial shareholders in this Company, consent to submit themselves as additional directors. The present Directors trust that the nomination of these very representative shareholders may be cordially supported. Mr. Ebbsmith submits himself for election as a director for the ensuing year, upon the representation that his retirement at the present time would be detrimental to the interest of the Company, and upon the condition that he will be permitted to retire from the chair.

Auditors.—Messrs. Howard Smith, Slocombe, and Co., retire, and are eligible for re-election as auditors of the Company.

ELECTRIC DEPARTMENT.

Average per mile run. d.	d.	Dr.	£	s.	d.	£	s.	d.
		Electric haulage:						
3 37		Wages	1,978	16	3			
1 76		Fuel	1,034	14	5			
68		Stores	396	19	0			
·12		Water and lighting	70	8	4			
·17		Sundries	102	11	2			
——	6 10					3,583	9	2
		Machinery:						
·79		Wages	466	0	1			
3 71		Materials	2 176	0	1			
——	4 50					2,642	0	2
		Car repairs:						
60		Wages	353	0	4			
·39		Materials	228	11	4			
——	·99					581	11	8
		Traffic expenses:						
1 65		Wages	969	17	9			
10		Water and lighting	61	18	6			
·04		Stores	22	16	1			
·09		Stationery, tickets, and punch royalty	52	6	4			
·02		Sundries	8	14	7			
——	1·90					1,115	13	3
		Permanent way and buildings:						
·02		Wages	9	13	2			
1 61		Materials	946	7	2			
——	1·63					956	0	4
		General charges:						
·12		Stationery and incidentals	70	1	11			
·12		Salaries	73	8	8			
·07		Compensation	39	0	0			
·82		Rates, taxes, and insurances	481	10	0			
·21		Professional charges	125	7	9			
·09		Sundries	53	6	10			
——	1 43					842	15	2
	16 55					£9,721	9	9

Average per mile run. d.	Cr.	£	s.	d.
16 12	Traffic receipts	9,467	12	9
26	Advertisements	155	6	10
17	Balance to revenue account	98	10	2
16·55		£9,721	9	9

Note.—Miles run, 140,993; passengers carried, 1,257,399.

The auditors, Messrs. Howard Smith, Slocombe, and Co., chartered accountants, report: "We have examined the books of account, vouchers, and other documents relating to the accounts of the Company, and find the foregoing statements to agree therewith.

We are informed that it is the intention of the Directors to set aside out of the profits of the two years ended June 30, 1892 and 1893, the sum of £20,000 as a reserve against depreciation of assets, and we are of opinion that such provision is sufficient as regards all assets other than leasehold lines and parliamentary concessions, which apparently represent over £300,000 of the capital expenditure, and the present value of which we cannot estimate.

With the foregoing explanation we believe the balance sheet to be a complete and fair statement of the assets and liabilities of the Company, and the revenue and working accounts to truly set forth the transactions of the past year. (*See also special report below.*)

AUDITORS' SPECIAL REPORT.

We have been asked by the Directors to report upon two statements contained in a circular issued by the Birmingham Central Tramways Shareholders' Association, dated June 2, 1893. The first of these statements is as follows: "There is no reserve fund beyond the printed figures which appear in the balance sheet. It is absolutely non existent." In reply to this, we beg to state that in none of the reports and accounts laid before the shareholders has it been suggested that a reserve fund had been invested outside the business of the Company, or that the item "reserve fund" on the debit side of the balance sheet related to any other assets than those shown on the credit side. The reserve fund (£51,126) shown in the balance sheet of June 30, 1892, had been created by transfer thereto of £32,903 premiums on new ordinary shares issued some years ago, less (£11,777) discount on debentures sold, and three sums of £10,000 each charged against the profits of the Company for the years ended June 30, 1889, 1890 and 1891, in accordance with the resolutions passed on the recommendation of the Directors. In our reports on the accounts for those years we stated the reasons why such sums should be set aside, and we further stated that there was a portion of the capital outlay of the Company in respect of which no depreciation had been made. If these three sums of £10,000 each had not been so appropriated, it would have appeared that they were available for dividend. They were, in fact, employed in the business of the Company, and if they had not been so retained and employed, the amount of lost capital to be provided for in any reduction of capital would be increased by £30,000. In the year 1892 a proposal for writing off part of the capital outlay by reduction of share capital was mentioned in the report of the Directors, and for that reason our report on the accounts referred only in general terms to the necessity for a proper addition being made to the reserve against depreciation of assets. The second statement is as follows: "The debenture debt cannot be increased." Upon this we would remark that debentures are issued upon condition that the Company "shall not borrow at any time on mortgage or debenture more than one third of the amount of the subscribed capital of the Company for the time being."

The subscribed capital is	£488,000	0	0
And one third of that amount is	162,666	13	4
The amount borrowed on mortgage or debenture is	144,600	0	0
Therefore the debenture debt can be increased by	£18,066	13	4

BUSINESS NOTES.

Portsmouth.—The chimney shaft at the electric light station in Gunwharf road has been completed. It is 122ft. high.

Southampton.—The docks recently acquired by the South Western Railway Company are to be lighted by electricity.

York.—As will be seen by our advertisement columns, the Technical Instruction Committee of the city of York require tenders for the electric lighting of the institute.

Bournemouth.—The amended estimate of Messrs. Dawson's to erect call bells for £137. 10s., and to maintain them for £17. 10s. per annum, has been accepted by the Town Council.

St. Pancras-Charing Cross Railway.—On Tuesday the Lords' amendments to the Hampstead, St. Pancras and Charing Cross Railway Bill were agreed to by the House of Commons.

Brighton.—The Town Council, as will be seen by our advertisement columns, invite tenders for the supply and erection of fittings for lighting the Municipal School of Science and Art.

Personal.—We understand that Mr. Johnson, secretary and manager of the Sheffield Electric Light and Power Company, sailed for New York by the "Britannia" on the 9th inst. *en route* for Chicago.

Electric Construction Corporation.—Mr. Justice Vaughan Williams has granted a supervision order in the case of the Electric Construction Corporation, the object being to reconstruct the Company.

Newcastle.—The City Lighting Committee have decided to present a report to the Watch Committee requesting them to consider the advisability of acquiring the electric lighting of the city generally.

Power from Refuse.—The experiments which have been in progress at Halifax with a view to bring into practical use a patent for generating power by the burning of refuse are, it is said, likely to lead to the floating of a company.

Liverpool.—In connection with the great fire at Liverpool on Saturday night, the overhead electric railway, running by one of the burnt timber yards, was slightly burnt for a length of about 50ft., but not to such an extent as to interfere with the traffic.

General Electrolytic Patent Company, Limited.—This Company has been registered by W. Bohm, 23, Old Jewry, E.C., with a capital of £24,000 in £1 shares. The object is to enter into an agreement for the acquisition of certain patents, and to develop the same.

Manchester Central Station.—We are informed by Messrs. E. Green and Son, Limited, of 2, Exchange street, Manchester, that they have put down at the central station a large economiser in connection with the boiler plant, and that it will result in a great saving in fuel.

City and South London Railway Company.—The receipts for the week ending August 6 were £801, against £919 for the same period last year, or a decrease of £118. The total receipts for the second half year of 1893 show an increase of £286 over those for the corresponding period of 1892.

Ambleside.—At the monthly meeting of the Local Board a letter was read from the Holloway Electric Company, and also from Messrs. Fell and Son, of Troutbeck Bridge, respecting the laying of electric wires. The Holloway Company were going to apply for a provisional order to supply the Ambleside Local Board.

Derby.—A general trades and industrial exhibition is being held at Derby. The exhibits, which belong mostly to local firms, are classed under four general heads—namely, engineering, electrical, inventions, and manufactures. There are altogether 106 exhibitors, 76 of whom are local tradespeople and manufacturers. The most prominent feature of the exhibition is, perhaps, the electrical machinery.

Salt Lake City.—The Gas, Water, and General Investment Trust are offering for subscription 1,250,000dol. 6 per cent. first mortgage bonds at the price of £205 per 1,000dol., secured by a registered first mortgage over the properties of the Salt Lake and Ogden Gas and Electric Light Company, subject only to outstanding bond issues, amounting in all to 110,000dol., which will be paid or provided for out of the present issue.

Burnley.—Supplementing our remarks of last week concerning the condition of electric lighting, Alderman Lancaster, at the meeting of the Town Council, said that as soon as the plant was completed the committee proposed to have an exhibition of electrical apparatus, lamps, switches, etc., and to throw it open as far as possible to the public, so that they could go and inspect the station, and see what could be done with the electric light.

Agency.—Mr. L. H. Bloomfield, of 11, Queen Victoria street, E.C., informs us that he has taken over the sole representation in the United Kingdom of Messrs. O. L. Kummer and Co., electrical engineers, of Dresden. Mr. Bloomfield will undertake the laying down of plant of every description. Messrs. Kummer and Co. are large makers of accessories for electric lighting, as, for instance, carbons, insulators, lampholders, switchboards, volt and ammeters, accumulators, portable batteries, etc.

West Bromwich.—At a meeting last week of the Town Council, the Highway Committee reported that they had received a communication from the Board of Trade granting an extension of the time for the use of steam on the South Staffordshire tramways till April 1st next, upon the understanding that the company will promote an order in the next session of Parliament to substitute some other motive power for steam, in which case there is to be a further extension for nine months to enable the works to be carried out.

Chesterfield.—On Tuesday, Alderman Wood, at the quarterly meeting of the Town Council, in moving the adoption of the minutes of the Electric Lighting Committee, said the Council would see from the report of the engineer that until a circular had been sent out to those residing within what the engineer termed the trade area, and replies were received saying how many lamps they would take, they could not proceed much further. When replies were received figures would be laid before the Council. The minutes were adopted.

Wakefield.—At a meeting last week of the City Council, the minutes of the Sanitary Committee contained the following: "The report of the Electric Lighting Sub-Committee, laid before the last meeting with respect to the visit made by them to Leeds on the 21st ultimo, when they inspected the lighting station of the Leeds Electric Supply Company, Limited, and the works of Messrs. John Fowler and Co., Limited, was again read, and the town clerk was directed to write Mr. Hammond, of London, and make an appointment with him to meet the committee on the 26th inst."

Canterbury.—The Electric Lighting Committee of the Town Council recommended last week the approval of the transfer of the Canterbury Electric Lighting Order, 1891, as amended by the Board of Trade. The Mayor said the committee found that the slight alterations made by the Board of Trade in the electric lighting order were rather in favour of the company than the Corporation, showing that the city representatives had exacted quite as much as was due to them. They had accepted the alteration in the agreement and were only awaiting the confirmation of the Dover people.

The Strand.—The Strand District Board of Works have had under consideration the electric lighting of the Strand by the Metropolitan Electric Light Company, who proposed to substitute for the present 67 gas lamps, costing £473. 11s. 11d. per annum,

22 arc lamps at a yearly cost, including renewals of carbons, cleaning, and all attendance, of £1,195 per annum, on the assumption that half that number of lamps would be extinguished at midnight. As, however, the increase in cost over the present system of lighting by gas would be more than 100 per cent., the Board decided not to adopt the electric light until it became cheaper.

Keighley. The subject of electric lighting was discussed by the Town Council on Tuesday on the occasion of the recommendation of the Gas Committee to apply for borrowing powers to the extent of £30,000 for gasworks extension purposes. It was urged that the committee should take steps towards furnishing a supply of electric light, but Alderman Brigg said they were carefully watching experiments, and it might be possible to find some system cheaper and better than that in use in many places. But however that might be, it was generally found that the adoption of electric lighting did not diminish, but rather increased, the consumption of gas. The recommendation was adopted.

Eccles. The electric lighting order promoted by the Town Council has received the Royal assent, and copies of the order have been furnished to members of the Borough Council. The second schedule to the order provides that within two years sufficient and suitable mains shall be laid to light various streets. The first schedule states that the area of supply shall be the whole of the borough of Eccles, and in addition to the mains specified the Corporation shall at any time after the expiration of 18 months after the commencement of the order lay down suitable and sufficient mains for general supply through every street of the borough upon being required to do so in the manner provided by the order.

Aberdeen. The Gas Committee of the Town Council have recommended the Council to fix the price for the supply of electricity to private consumers at 7d. per Board of Trade unit. The Gas Committee, at a meeting of the Town Council on Monday, submitted a list of candidates for the appointment of electrical engineer, and stated that one of the applicants, Mr. A. H. Gibbings, Sussex, had withdrawn, having received an appointment in Hull. A vote was taken between the other three candidates—viz., Mr. J. Christie, Glasgow; Mr. E. T. Ruthven Murray, Larne, co. Antrim; and Mr. A. C. Nixon, Belgravia, London. On a division, Mr. Murray was declared to be elected, the remuneration being £200 per annum.

Rugby School Electric Lighting Company.—Under this title a company has been registered to supply electricity to the boarding houses and to the buildings of or connected with the school, and all buildings occupied by persons residing in Rugby holding appointments in the school or in connection therewith. The nominal capital is £5,500, divided into 110 shares of £50 each. The registered address is Dunchurch road, Rugby. The subscribers to the articles of association are: J. Percival, J. Collins, F. D. Morice, A. E. Donkin, W. Gordon Michell, W. Parker Brooke, G. Stallard, C. Godfrey Steel, and R. Whitelaw. At present it is only intended to supply the schools and boarding houses. The necessary buildings are being erected, and most of the plant is said to have arrived.

Fareham. At a meeting of the Local Board, the question of the contract with the electric lighting company for supplying light for the streets came on for consideration. The clerk read the contract as amended since the last meeting and it was pointed out that the only difference was that the lights were now described, and that the penalties for inefficient lighting were reduced from 3d. to 1½d. per hour for arc lights, and ½d. per hour for incandescent lamps. The company agreed to give the same number of lights—20 arc lamps of 1,200 nominal candle power each, and 92 incandescent lamps of 20 nominal candle power each, for the sum of £549 per annum for a period of three years, the contract to be terminable by six months' notice if the light did not reach the proper standard. After a discussion, it was resolved that the contract be sealed with the company.

Rochdale Sanitary Works. The sanitary works of the Corporation have been electrically equipped by Messrs. Laing, Wharton, and Down, and the switching on of the light took place on the 4th inst. There are about 80 lights of various powers—ranging from 16 candles to 50—and they illuminate the whole of the works, stables, offices, yard, etc. The lamps are arranged so as to suit their varied positions. A slow-speed incandescent light dynamo is worked by the waste power of the engine which drives the machinery, so that there is practically no extra cost for motive power. The engine is equal to about 100 h.p., and since the stoppage of the pulsometer at the sewage works it is quite capable of doing more work than it does now. The boiler fuel consists entirely of rubbish, no coal being used. The arrangements are made so that the number of lights could easily be doubled if necessary. The Health Committee of the Corporation met to start the lighting, and Councillor Hardman said these were the only sanitary works in the world in which the electric light was in use. He also remarked on the fact that the driving power was obtained from refuse which in other towns was thrown away and wasted. The Health Committee were to be congratulated on their economical and progressive policy.

Stafford.—Last week, at a quarterly meeting of the Town Council, the Electric Lighting Committee recommended the carrying out of the scheme proposed by Mr. Bell, gas engineer, and endorsed by Dr. John Hopkinson, and that application be made to the Local Government Board for authority to borrow £20,000 for the erection of buildings and an electrical installation, £12,000 of which was to be spent at once. Alderman W. H. Peach (chairman of the committee) proposed the adoption of the report. Dr. Hopkinson did not suggest any street electric lighting at present, but only to supply private consumers. He gave it as his opinion that they could supply the electric light at a small profit with 15,000 to 20,000 lamps. Mr. Peach pointed out that they had got customers who would have 15,000 lamps at the price of 7d. per unit, which was the price which the committee proposed to charge. The system recommended was the continuous current low tension one. This was thought to be the best for Stafford, as it lent itself most readily to extension when required. Councillor Wormal seconded, and after some discussion the report of the committee was carried. On the recommendation of the Gas Committee, it was resolved that sufficient land be set apart at the gasworks for a site for the electric supply station, and that Mr. Bell be requested to prepare plans, etc., for the necessary works.

Bolton.—A central station is to be erected in Spa road, and tenders are now being obtained by the architects, Messrs. Hinnell and Murphy. The station is to be erected on land belonging to the Gas Committee, the offices having a frontage to Spa road, and the engine and dynamo house, boiler house, chimneys, sheds, etc., being erected at the rear. The office buildings will be two storeys in height, the ground floor comprising enquiry, drawing, and engineers' office, with lavatory and other accommodation. The first floor will contain committee room, testing and accumulator room, and also a passage from which admittance is gained to the switchboard gallery. The offices are to be built with brick, faced with stone, the floors are to be of concrete and wood blocks, and the roof, which is of timber, is to be ventilated by means of tube inlets and flue outlets. The works buildings will consist of boiler house, 83ft. 6in. by 50ft., for accommodating six boilers, the requisite coal shoots, bunkers, and concrete water tanks; also circular chimney, 50 yards high, engine and dynamo house, repairing shop and storeroom, closed shed for stores, open shed in yard for carts, tools, etc., and railway siding. The engine and dynamo house and boiler house are to be built of brick, the floors being of concrete, and the roofs of wrought iron, that of the boiler house being louvred. The chimney is to be built of brick with stone capping, and provided with lightning conductor. The flues are arranged so that any number and any of the boilers may be worked at the same time. The engine and dynamo house will be provided with machinery entrance, iron ladder to switchboard gallery, with suitable foundations of concrete and stone.

Richmond Electric Lighting.—At the Richmond Town Council last week the Electric Lighting Committee reported as follows: "The committee have been in communication with Latimer Clark and Co. on the subject of the lighting of the public street between the Kew road railway bridge and the bridge over the river, and the matter is now referred to Messrs. Urquhart and Small, the newly-appointed electrical engineers to the Corporation, for consideration and report. The feeding mains for the electric light have been laid in Eton-street, and the distributing mains are now being laid on one side of George-street, leaving the other side to be done when the fire call cables are ready to be laid, thus avoiding the reopening of the pavement trenches. Mr. Shoolbred has declined the offer of the Council to pay him £105 in respect of his charges against the Corporation, and the matter having been placed in his solicitor's hands, is left with the town clerk, who has received a communication from the solicitor, and the committee will be able to report further hereon hereafter. Meanwhile the clerk was instructed to ask for all plans and papers in Mr. Shoolbred's possession, which have been obtained." Councillor Christie urged the need of watching the manner of the erection of the electric lighting works now in progress, with a view to what the Council might have to pay for them when eventually taking them over. The Mayor said that at the end of 30 years the Corporation would take over the works at a valuation, and not upon the basis of what they cost. Councillor Ryan had a notice upon the paper, to move "That the reports of and correspondence with Mr. Shoolbred, C.E., and the Electric Lighting Committee, be printed." He consented to adjourn his motion, as the Council had been sitting for more than four hours.

Fire Alarms at Richmond. The Richmond Town Council have decided to have a system of fire alarms instituted throughout the borough, and at the monthly meeting last week the Works Committee presented a supplementary report on tenders for electrical apparatus as follows: "Electric Fire Calls.—The committee have received a number of tenders for these works, the list of which will be laid on the table at the Council meeting. They recommend the Council to accept the tender of Messrs. Blinko and Co., of 34, Leadenhall street, £899. 10s. (the lowest tender), for cables, wires, boxes, etc., and their tender at £153. 10s. for instruments and apparatus, together £1,053, subject to the sureties being satisfactory, and that the contract be sealed. The committee also recommend that they be allowed to have the work carried out forthwith." The Mayor said that since the report was presented it had been thought that it might be better to accept the tender of Messrs. Callender and Co., £980. 19s. 6d., in preference, for the cables, as they were the makers, and this might ensure more prompt delivery. He moved that that tender should be accepted, and that the question of the tender for instruments should for the present be left over. Councillor Ryan thought the Council would be acting wisely in adopting this amendment. The question of time was very important, and he did not think that it would be well to give the contract simply to the lowest tenderer. He also thought that no tender for instruments should be accepted before the most careful enquiry had been made with regard to the ability of the firm to fill it. The Mayor's recommendation was adopted. Councillor Bickerton enquired what limit of time there was during

which the company would be bound to make good the roads and footpaths disturbed. The Mayor said the surveyor made good the places disturbed at the expense of the contractors.

Cheltenham. -The report of the Electric Lighting Committee of the Town Council, presented on Tuesday by Mr. George Norman (chairman of the committee), recommended the adoption of the high pressure alternating-current system for the town, the supply to be undertaken by the Corporation, using the ash destructor site for the station. Mr Norman explained that Mr. W. H. Preece had given the committee the benefit of his advice. In the course of his interview with the committee, Mr. Preece said he had the strongest belief that the only satisfactory system which they could introduce, and which would give proper financial results, was the high pressure system. The low pressure system would mean that they would require a central station in a central part of the town, and that they would have to expend a large sum of money in mains. The high pressure system meant that they could place their station anywhere, and that they would not have to spend so much money in mains The ash-destructor station was eminently adapted for a central station, as the destructor would always be at work, and this was an element of considerable economy in the working expenses. He had no doubt as to the success of the light. He would not go so far as to say that in the first year they would make sufficient to pay interest on redemption fund, but they would cover their working expenses; and in the second year there was not the slightest question they would clear sufficient to pay interest and provide a sinking fund as well. Dealing with the question of cost, Mr. Preece said "Gas at 3s. per 1,000 is equivalent to electricity at 6d. per unit. Therefore if you introduce your electricity as you propose, at 6d. per unit, you are introducing a light which is equivalent to gas at 3s. per 1,000ft. If you get a large *clientèle* and have also a long use for the light your cost would come to less than 4d per unit, and you would be in a position to reduce the charge to perhaps even less than 3d. per unit." Mr Norman having moved the adoption of the committee's recommendation, Alderman Colonel Moyts seconded the motion, which was adopted.

Gas and Electric Lighting in Glasgow. -The report by the Committee of Gas Supply and Electric Lighting for the year ending May 31 has been issued. The gross revenue of the gas department for the year amounts to £594,049, and the gross expenditure to £464,449, to which is added depreciation, written off capital, £34 419, leaving a balance of £95,181 to be carried to profit and loss account. After meeting payments for annuities on stock, interest on borrowed money, and sinking fund, there remains a surplus on the year's operations of £29,539 Out of this sum the committee have met the balance at the debit of previous year's accounts of £26,139, the loss on the electric lighting account of £1,773, and have transferred to insurance fund £1,500, leaving a balance of £126. In the electric lighting department the gross revenue from March 1, 1892, to May 31, 1893, amounted to £7,784, and the gross expenditure to £5 416, to which was added depreciation written off capital, £1,328, leaving a balance of £1,039 The committee had to meet interest on loans, £2,012 18s 10d., payment to sinking fund, £800; and, deducting these sums from the credit balance, there remained a deficiency of £1,173, which was transferred to the debit of the gas account. The above result was not unexpected by the committee during the first year's operations. The capital expenditure on the new system during the greater part of the year was unproductive of revenue, and in the meantime interest had to be paid upon the money borrowed. The committee fixed the price of electric energy from June 1, 1892, at 7d per Board of Trade unit, at which price they recommend it should be continued for the current year. During the period of this account the committee had purchased ground at the corner of Waterloo and Mains streets, and have erected thereon a central supply station, which, with machinery and plant, has cost £44,000. The committee were glad to state that not only will these works be fully employed during the winter, but that it had already been found necessary to extend the plant in order to meet the increasing demand for current, and they hope that the future reports of this enterprise will show an increasing prosperity from year to year. The number of consumers when the undertaking was acquired by the Corporation was 37, while the number at May 31, 1893, had increased to 108.

Glasgow.—The question of the municipalisation of telephones came up for discussion at the quarterly meeting of the Town Council on the 3rd inst Mr. Starke, in moving the approval of the minutes of the Telephone Committee, and of the relative minute of the Finance Committee, said the committee had resolved to recommend that an application be made to the Postmaster General, in terms of the Treasury minute of May 23, 1892, for a license to supply the community with an efficient telephone service A deputation of the Telephone Committee afterwards met with the Finance Committee for the purpose of seeing as to ways and means by which the proposal might be carried out. The Finance Committee heard their statement, and gave it a hearty and generous response, and "resolved to concur in the recommendation of the special committee that an application should be made for a license They further agreed to recommend that the Corporation should advance the sum necessary to start the system, but that, after the license is obtained, the first opportunity should be taken to apply to Parliament for statutory powers" There was a general feeling that this matter must be taken up by the State or by the municipal authorities in connection with the State. Having explained the position of the Government in the matter and that they had erected two great trunk lines between London and Glasgow and one between London and Edinburgh, with branch lines from them to the large English cities, Mr. Starke contended that it lay with municipalities to provide an adequate local service. It was becoming, he said, that Glasgow, among all the great corporations, with the prestige she held as a bold and successful exponent of municipal enterprise, should step out and be the first in the direction of dealing with the telephone service. There were other cities watching very carefully what they did that day, and which might follow in their footsteps. The system in Glasgow, which was a single wire system, was totally unfitted for such a great city. On the financial aspect of the question, Mr. Starke said that so far as they could get reliable estimates they could lay down a new system in Glasgow for 3,500 users for £52,000. As to the financial arrangements, he pointed out that 3,500 subscribers at £5 per head would amount to £17,500, and there would be at least 2,000 private instruments, which would make the income £19,500. The working expenses might be reasonably taken to mean 50 per cent. of the revenue, while the Government license would be 10 per cent. on the net income. Then he proposed that 5 per cent. should be set aside every year as a sinking fund, so that the whole should be wiped out in 20 years. He thought they were entitled to take from that the interest which would accrue on the subscriptions paid in advance. Allowing £2,000 for sundries, he estimated they would have a clear revenue of between £5,000 and £6,000 per annum. Bailie Alexander seconded the motion. Bailie Primrose moved that the whole subject be remitted to a committee for further consideration, with instruction to report fully and in detail. After further discussion, the motion as amended was adopted.

Hampstead. The results of tenders will be found in our last issue, but it may be useful to be able to compare the amounts, so we give the report of the committee on the subject "1. For the erection of a chimney shaft and buildings for the proposed central electric supply station, with foundations for the machinery, etc. 2. For the plant for the proposed station and the provision of the necessary mains, etc., in the compulsory area. Your committee beg to state (1) That the following is a list of the tenders received in response to the advertisements issued—viz.: (a) For the buildings (including chimney shaft), 12 tenders:

Yerbury and Sons	£10,870
Killby and Gayford	10,634
Holliday and Greenwood	10,555
Simmons Bros	10,300
Reid, Blight, and Co.	10 300
Chessum and Sons	10,185
Neil	10,000
Wall Bros	9,825
McCormick and Sons	9,700
Ballard	9,477
Allen and Son	9,339
Allen and Son	9,189

(b) For the plant—31 tenders, of which number six only were from firms tendering for the whole of the sections included in the specifications—viz.:

Brush Company	£22,047
Latimer Clark and Co.	21,850
Latimer Clark and Co. (alternative tender)	21,129
Sharp and Kent	21,572
Crompton and Co.	21,512
Electric Construction Corporation	21,232
Siemens Bros and Co.	19,914
Siemens Bros. and Co. (alternative tender)	19,120

(2) As to the buildings: The prices being much in excess of the estimate, your committee appointed a sub-committee to examine, in conjunction with Mr. Preece and the architect, the drawings and specifications with a view to see whether, with a due regard to efficient work, any saving in expense could be secured in constructing the buildings and shaft. The result of this examination was that certain modifications were determined upon, the plans and specifications were revised, and the parties tendering also revised their estimates in accordance therewith, the same now being as follows:

Wall Bros.	£8,425
Reid, Blight, and Co.	8,295
Killby and Gayford	8,270
Neil	8,092
Holliday and Greenwood	7,836
McCormick and Sons	7,794
Simmons Bros.	7,536
Yerbury and Sons	7,350
Chessum and Sons	7,344
Ballard	7,207
Allen and Son	7,100

After careful consideration your committee have determined to recommend that the tender of Messrs. R. A. Yerbury and Sons, of Birchington road, Kilburn, for the erection of the chimney-shaft and buildings for the proposed central electric supply station at the parish stoneyard, Lithos road, with foundations for the machinery, etc., in conformity with the specifications and plans prepared by Mr Preece, for the sum of £7,350 be accepted. The original estimate for the buildings was £6,000, but the committee considered it advisable to build at once a chimney shaft large enough to accommodate the machinery required for lighting the whole parish, and so to arrange the building as to hold one extra boiler, and to be easily adapted for extensions. The larger shaft was estimated to cost at least £1,000 extra. It will, therefore, be seen that the actual tender recommended for acceptance is only £350 above the estimate. (3) As to the plant:

A long report on these tenders was presented by Mr. Preece, who pointed out that he had found it advisable, in view of future requirements, to add an extra boiler, and also to increase the size of one of the steam dynamos. These alterations entailed an extra cost of about £1,000 After carefully considering the question of efficiency of the machinery proposed, and the experience in the type of machinery required, your committee resolved to recommend that the tender of Messrs. Siemens Bros and Co., of 12, Queen Anne's gate, Westminster, for the supply of electric lighting plant, for proposed installation at the parish stoneyard, together with the necessary mains, etc., for the compulsory area in conformity with the specifications and plans prepared by Mr. Preece, for the sum of £19,794, be accepted Note. This sum of £19,794 represents Messrs. Siemens's tender of £19,914, subject to a deduction of £120." As we stated, the tenders of Messrs Yerbury and Sons for building and of Messrs. Siemens for plant were accepted, and the Electric Lighting Committee is now left to carry out the work.

Peterborough. -A public meeting was held last week at the Angel Hotel, under the presidency of the Mayor, to consider the question of electric lighting The Mayor, in introducing Mr. Hammond, said there were some difficulties at present existing in the minds of the Corporation as to whether the time had arrived when they should take up this subject. Hitherto Peterborough had been pretty well to the fore in railways and many other things, and he did not think they would allow the town to be backward in the matter of electric lighting Mr Hammond then gave an explanation of how the electric light was generated, and the manner in which it was distributed He claimed for the light a great superiority over other artificial illuminants, one most important feature being the fact that it did not feed upon the air, as was the case with gas or lamps, which robbed the atmosphere in a room of its life-sustaining properties. Another great advantage of the electric incandescent lamp was its absolute freedom from danger or fire, it being quite impossible to light anything from an incandescent lamp because immediately the glass containing the light was broken the light went out The electric light did no damage to ceilings and furniture. Recent improvements insisted on by the Board of Trade had made electric lighting free from the possibilities of serious accidents, the pressure required to light an incandescent lamp being so small that should a person touch the wires so as to bring them into contact, there would be no danger whatever. The electric light was so convenient to turn off and on, no matches being required, that a great difference was thereby saved in the cost. Dealing with the cost, Mr Hammond said some people were inclined to wait before going in for electric lighting, under the impression that there would would be a marked reduction in the cost in a few years, but this he said was a mistaken notion, for as far as apparatus was concerned, they had got very nearly to the lowest level There was every reason to gather from Board of Trade returns that electricity could be produced and distributed at a profit at 6d per unit, which was equivalent to gas at 3s and 3s 4d per 1,000 cubic feet. Some of the companies were making a profit at 4d per unit, but 6d. would equal the price paid in Peterborough for gas The present Act under which electric lighting was carried out was very strict, and there was not a single instance of a system laid down under this Act that had not been a success, and there was not a single house to house supply system that had proved a failure Electrical works at present in operation had absorbed four and a half millions of capital, of which amount four millions was provided by the companies, and half a million by local authorities, but if they considered works at present in hand and others for which sanction had been obtained, they found the capital provided by companies had only increased to £4,188,000, whilst that of local authorities had risen to £2,000,000 The electric lighting business at the present time could be shown to be on a sound basis, and some towns which had allowed private companies to step in and supply the light were already talking of buying the companies out. The cheapening of the incandescent lamp made him confident that in a very short time they would be able to supply electricity at a cheaper price than gas, to say nothing of its other innumerable advantages In reply to Councillor Nichols, Mr. Hammond said he should say they could make a very profitable beginning in Peterborough with a capital of £9,000 or £10,000 At the close of the proceedings it was decided to memorialise the Town Council to either adopt the electric light or allow a private company to step in.

PROVISIONAL PATENTS, 1893.

JULY 31.

14640. **A form of water actuated electric switch.** Alfred René Upward, 150, Holland road Kensington, London.

14643. **Beboutoff's automatical and electrical pile or monkey driver.** Prince Abessalum Beboutoff, Fincastle House, Queen's terrace, Middlesbrough

14647. **Improvements in apparatus for working electric tramways by means of underground cables.** Christopher Anderson, Lane House, Jack lane, Hunslet, Leeds

14664. **Improvements in electromotors for alternating currents.** John Augustine Kingdon, 29, Marlborough hill, St. John's Wood, London

14685. **Improvements in and relating to apparatus for heating and warming by electricity.** Lionel Herbert Hordern, 70, Chancery-lane, London.

AUGUST 1.

14715 **Improved bell-pull arrangement for electric bells.** Edgar Godwin Harcourt, 13, Temple street, Birmingham.

14742. **Improvements in or appertaining to electric light fittings.** Frederick William Plumstead and Henry Hatt Hunter, 121, Chancery lane, London

14756. **Improvements in dynamo-electric generators and motors.** Alfred George Brookes 55, Chancery lane, London. (Harris Joseph Ryan.) Complete specification.

AUGUST 2.

14816. **An improved electromotor for boats and like purposes.** Albert Antoine Lateulère, 97, Newgate street, London.

AUGUST 3.

14863. **Improvements in electrical resistances.** Albert Campbell, Ballynagard House, Londonderry.

14868. **Improvements in electricity meters.** John Thomson, 87, St Vincent street, Glasgow.

14910 **A method of and apparatus for electrolytical decomposition while using quicksilver as cathode** Peter Jensen, 77, Chancery lane, London. (Alf Sinding-Larsen, Norway.) (Complete specification.)

AUGUST 4.

14953. **Improvements in regulating the supply of electricity to incandescent lamps** Thomas Budworth Sharp, County chambers, Martineau street, Birmingham.

14966. **Improvements in the construction of loud-speaking micro telephones.** Edward Morway, 27, Chancery-lane, London.

14969. **Improvements relating to two-pole dynamos motors, and the like** Francis Murray Newton and Tom Hawkins, Norfolk House, Norfolk street, London.

14979. **Improvements in electric lighting and signalling apparatus for use on cycles and other vehicles** Alfred Julius Boult, 323, High Holborn, London. (Carl Duvivier, Belgium.)

14997. **Improvements in electric contacts for telegraphic vibrators.** Edmund Edwards, 35, Southampton buildings Chancery lane, London. (Paul la Cour, Denmark)

15001. **Improvements in telegraph forms** Cyril Arthur Pearson and Frederick Jonathan Gallaher, 37, Chancery lane, London.

AUGUST 5.

15025. **An electric plant protector.** Francis Alexander James FitzGerald, 27, Upper Merrion street, Dublin

15050. **Slow striking electric bells.** Hermann Oppenheimer, 55, Redcross street, London.

15064 **An improved electric arc lamp** Frank West Suter and Sydney John Suter, 28, Southampton buildings Chancery-lane London

15073 **Improvements in electric arc lamps.** Henry Hayes Cooper and the Electrical Installation Company, Limited, 53, Chancery lane, London

15074. **An improved electric coupling.** Henry Hayes Cooper and the Electrical Installation Company, Limited, 53, Chancery lane, London

SPECIFICATIONS PUBLISHED

1892.

13395. **Electrical signalling.** Mercier.

13543. **Electrical installations** Siemens Bros and Co., Limited. (Siemens and Halske

16046 **Electrolytic decomposition of alkaline salts.** Castner.

16489. **Electrical rock drill.** Taylor

17691. **Cutting glass by electricity.** Havaux

1893.

10347. **Battery switches.** Spangenberg

11143. **Electrical switches, etc.** Dorman and Smith

11622. **Magnetic separation.** Sanders and Thompson

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3½
— Pref.	—	2¾
City of London	—	11
— Pref	—	12¾
Electric Construction	—	—
Gatti's	[illegible]	5¼
House to House	5	5½
India Rubber, Gutta Percha & Telegraph Co	10	22½
Liverpool Electric Supply	5	6¼
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	6
National Telephone	5	4¾
St. James', Pref.	—	8
Swan United	3¾	3¼
Westminster Electric	—	5½

NOTES.

Verdun.—The local gas company is lighting the Grand Theatre by electricity.

Bilbao.—The electric light has been installed in the telegraph station at Bilbao.

Bournemouth.—The new Hotel Metropole, opened on Tuesday, is lighted electrically.

Bernburg.—Electricity works are shortly to be erected here for lighting purposes, and for the working of an electric tramway.

Motte-Chalencon.—The electric light installation in this town has been experimentally run, and lighting is now being commenced.

Bournemouth.—We understand that a station for the charging of carriage, police, cycle, and portable lamps is to be opened in a few weeks.

Metz.—The military hospital is to be lighted by electricity; the motive power to be obtained from the fall of water at the Sauley Island.

Grasse.—The subject of connecting Grasse with the railway station by means of an electric tramway two miles long is under consideration.

The Azores.—The steamer "Seine," which has been chartered to lay the new cable between Portugal and the Azores, left Lisbon on Sunday.

Whitworth Scholarship.—A scholarship worth £125 a year, tenable for three years, has been gained by Mr. W. Hamilton, electrical engineer, of Glasgow.

Induction.—The working of the electric tramway started between Herstel and Wandre, Belgium, a short time ago, has caused disturbances in the telephone wires carried alongside the line.

Oil Insulation.—We are glad to learn that the oil-insulated system of underground mains is working satisfactorily. The mains can now be laid for the transmission of current at any voltage.

Franco Swiss Telephony.—The conditions under which telephonic communication is to be carried on between France and Switzerland have been published by the Government of the former country.

Villa Borghese.—An electric tramway just over one mile in length has been put in operation to connect the Porte Pinciano and the Villa Borghèse. There are three cars in service on the storage battery system.

Hamburg.—The preparations for the working of the tramways by electric power have been well advanced by the Union Electricity Company, and the belt line is proposed to be set in operation in November.

Paris.—The formation of a new company is spoken of in Paris for the electrical transmission of power over long distances. For this purpose it is intended to utilise water power in the midlands and south east of France.

Underground Conduits.—The large orders mentioned in another column as having been obtained for the Johnstone system of underground conduits show that this system has obtained a firm footing in this country.

Commerce.—The furtherance of technical education and the adoption of the decimal system will be considered at the autumn meeting on September 26 and 27, to be held at Plymouth, of the Associated Chambers of Commerce

Miners and Electricity.—The members of the society frequenting the Bergmannstag at the meeting at Klagenfurth, Austria, on Wednesday and yesterday, are considering, among other matters, the subject of electricity in mining.

Obituary.—The death has just occurred at Canonbury of Mr. W. S. B. Woolhouse, F.R.A.S., who was a well-known mathematician. He contributed to the *Philosophical Magazine* for May, 1860, a paper on "The Deposit of Submarine Cables."

Milan.—Operations have already been commenced at Milan by the Edison Company on the work of constructing the electric tramway on the overhead trolley system. The generating station contains steam-engines, driving two dynamos of 150 h.p. each.

Transmission of Power.—A concession has been asked for by a Frankfort company for the utilisation of the water power of the Lech, near Gersthofen. The available water power amounts to 5,000 h.p., and it is proposed to transmit this to Augsburg and the neighbourhood.

Gas, Electricity, and Water.—In Rhineland and Westphalia these subjects are treated at meetings of a society constituted to consider the three interests, and usually information of much value is adduced. At the general meeting, however, just held, nothing of importance as regards electricity or gas was brought forward.

South London Railway.—The bursting of a water-main at the Oval Station of the City and South London Railway on Tuesday evening caused considerable inconvenience. The main conveys water for operating the hydraulic lifts. Before the supply could be turned off the water partially flooded the line, and it was with great difficulty that trains could proceed.

Simultaneous Contrast Colours.—The very interesting article by Mr. Alfred M. Mayer on "Simultaneous Contrast Colours, and a New Photometer for Measuring Lights of Different Colours," which we recently mentioned, is given in the *Philosophical Magazine* for this month. It is certainly worth reading in full by those interested in photometrical studies.

The Remscheid Tramway.—The popularity of this electric tramway is shown by the fact that during the first four weeks that the line has been at work, no less than 65,674 passengers have been carried. A third generating set—boiler, engine, and dynamo—is to be laid down and five new cars put into service. This is good progress considering that the tramway was started only at the beginning of July.

Electrical Purification of Sewage.—Some interesting experiments in this direction are being carried out in the most populous and unhealthy part of Havre, and they concern the destruction of the impure elements in both liquid and solid sewage. Hopes are entertained that the results of the experiments will facilitate a solution of the problem relating to the drainage of Havre, upon which the municipality is about to spend £400,000.

Switches.—A revised price-list of fittings has been issued by Mr. A. P. Lundberg, of Bradbury street, Kingsland, N. One of the chief specialities made is the "Unique" switch, which we described some time ago, and the popularity of which is shown by the fact that since its introduction last year nearly 30,000 have been disposed of. Illustrated descriptions are given of the "Unique" main and other switches, sockets, ceiling roses, etc.

Electricity in Mining.—An important installation has been carried out at the Ziegler pit of the Blattnitz steam-coal mines at Nurschan, near Pilsen. On the surface is arranged a steam-engine of 120 h.p., which drives a continuous-current dynamo used for lighting the under-

ground roads. Here the current is employed to actuate various motors which operate hauling engines, ventilators, pumps, and a chain tramway. It is shortly intended to increase the plant and lay down two rock-drills.

Price of Gas.—The members of the Gas Consumers' Protection League, recently formed to obtain a reduction in the price of gas supplied by the Gaslight and Coke Company, and generally to protect the interests of gas consumers north of the Thames, met on Wednesday at the Foresters' Hall, Clerkenwell-road. The members would do well to support an electric light scheme, and although they may have to pay more for the light, they would not grumble about that, because of its superior advantages over gas illumination.

Crystal Palace School of Engineering.—On Saturday the thirty-third session was terminated, and the successful students received their first-class certificates. The examiners' report specially dwelt on the importance of the electrical section. The following were the most successful students: H. A. Bailey, W. Collins, G. Stirling, R. H. Pocklington, P. H. J. Bishop, W. C. Gravely, T. A. S. Dyer, D. Clark, J. Braby, H. T. Cressy, R. H. Hayne, F. H. Hodson, J. C. Lyell, R. F. Skinner, H. F. Deslandes, A. D. O. Travers, and M. G. Bradford.

Birmingham Electric Cars.—The proceedings at the annual meeting of the Birmingham Central Tramways Company on Wednesday were of an animated character. As the chairman mentioned, the conclusions of the Joint Parliamentary Committee on Electric Traction Powers had removed the restrictions which the telephone company had sought to place upon them. The company had been encouraged to proceed with negotiations which had been held in suspense, and which they believed would mean a profit to the company upon the Bristol-road line of not less than £2,000 per annum.

Richmond.—A correspondent complains of the erection by the electric light company of a high chimney in the centre of Richmond, and which he regards as an eyesore. He states that: "It may be urged, perhaps, that the lower part of the town is unpicturesque and commercial, and therefore that the interests and the feelings of the inhabitants are unworthy of consideration; but when this monster chimney is completed the dwellers on the hill will find that they too have their part in the nuisance, and that, intersecting the fine northward view and the wooded valley of Kew and Isleworth, there will stand a hideous shaft more suggestive of Oldham or Warrington than of a favourite West-end suburb."

Electric Cautery.—This subject was referred to in the evidence given before the Select Committee on the Marking of Foreign Meat. In their report, issued on Monday, the committee state that they are disposed to believe that after public attention has been called to the system of marking by electric cautery, the improvements of inventors and the experiments of agricultural societies and other bodies interested in this matter may develop a plan which, either alone or combined with that of affixing metal tags through the shank bones, would still further protect the customer. The committee were impressed with the fact that, owing to the greater thickness of the skin, the application of cautery to the sides of the animal was attended with considerably less injury both to skin and flesh than was the case with the shoulders or legs.

The National Telephone Company.—The *Pall Mall Gazette* states: "For recuperative energy the National Telephone Company is a difficult corporation to beat. It has survived the execrations of its London subscribers; seen the birth and ignominious extinction of the New Telephone Company, which was organised to crush it; passed through unsuccessful lawsuits that would have ruined any other company, and successful ones that would have broken a bank; it is in a fair way to elude the action of the new model tramway (electric) clauses for at least three years; and now an uneasy feeling is abroad that it has diddled the whole country over the negotiations for the national purchase of trunk lines, pocketing no inconsiderable portion of the sum voted, and handing over in return the one portion of its system which could not by any possibility ever pay by itself, and which it would be glad to be rid of at any price."

Technical Education.—The London County Council has issued circulars relating to their scheme of technical education, which is under the supervision of Prof. Garnett. Beside giving 200 minor scholarships to pupils from elementary schools, and inaugurating classes for cookery and dressmaking, it is intended to aid the evening science classes held within the administrative county of London. This aid will take the form of a payment for each student attending certain classes a stated number of times, also an additional grant for maintenance of laboratory. These payments are made in addition to the grants received from the Science and Arts Department. The special subjects mentioned for which assistance is to be given are mathematics, theoretical and applied mechanics, practical geometry, building construction, machine drawing, naval architecture, chemistry (inorganic and organic), physics, botany, geology, mineralogy, steam, navigation, and nautical astronomy.

Long-Distance Telephony.—In the *Philosophical Magazine* for August, Prof. Perry, assisted by H. A. Beeston, has a paper on "Long-Distance Telephony," treated from the mathematical point of view. As it is given to few men, he says, to discuss complicated mathematical formulæ without making mistakes, he has instructed his pupils to experiment with their formulæ, using numerical values for their variables. Some of his students have recently obtained numerical results which are embodied in tables given in this paper. The tables show the limiting distances in millions of centimetres for various amounts of leakage and self-induction (one million centimetres is equal to about six miles). Other tables give numbers which, divided by $\sqrt{kr}$ for any telephonic line, and also by the value, m (depending on the allowable variation), considered suitable, will give the limiting distances for that conductor. These tables neglect terminal conditions.

Electric Light and Cooking by Gas.—Towards the conclusion of a paper on "Cooking by Gas," read by Mr. J. Ballantyne before the North British Association of Gas Managers, the author said: "One thing is certain, that should the electric light become the light of the future (as it no doubt will to a certain extent in the course of time) those towns which have been fostering cooking and heating by gas will come out of the struggle with least loss. In our case, suppose we lost the whole 20 million cubic feet of gas now required for lighting purposes, we should still require to manufacture at least 12 millions for our gas stoves. This, then, is the weapon with which to fight the electric light. If this branch of our business were pushed as it might be, we need have no fear of seeing the electric light introduced, because all that would be more than regained by the gas required for cooking and heating purposes." This is a very candid statement, but the author has left out of consideration the subject of cooking by electricity.

Lighting at Halifax.—The application of the Town Council for permission to borrow £30,000 for the construction of a central station was considered on Wednesday by Colonel Hasted, R.E., on behalf of the Local Government Board. The application is made under a provisional order, and the scheme has been prepared by Mr. Wilmhurst, and approved by Mr. W. H. Preece. The permissive area of supply is the whole of the county borough, but the compulsory area is certain streets within the borough. The plant proposed to be put down at first will be sufficient for about 10,000 lights. The application was opposed on behalf of several ratepayers and the Halifax Electric Light and Power Company. The latter was formed in 1889, and had expended £6,000 in supplying a portion of the borough with the electric light. The company would have opposed the granting of the provisional order had they not received certain assurances.

Rheostats.—The carrying capacity and resistance of hot wires for use as rheostats are, says *Industries and Iron*, worthy of investigation. If iron is used there is an uncertainty about the temperature coefficient and the specific resistance, so that it is difficult to know beforehand what a given set of spirals will do. If a more expensive metal or alloy is used, what is wanted is to get the largest surface with the least metal—that is to say, the wires should be as thin as is compatible with mechanical strength and durability. This is often overlooked, and resistances for large currents are made of large wire, whereas several small wires in parallel would be cheaper. It is most important that rheostats for testing work should be made up to exact resistances or conductivities; so that in testing, say, a 100-volt machine, the current may be exactly 100 times the conductivity of the circuit arranged. This dispenses with an ampere-meter, a matter of great convenience, especially when the currents are large. The information wanted is the carrying capacity of spirals of different pitches and diameters of wires of different gauges of copper and various definite alloys.

Dead Wires.—Seeing that the National Telephone Company may be said to have won all along the line in regard to all competitors, it may be worth while to ask what is being or will be done with regard to the many dead wires which are to be found all over the kingdom. If there is any danger in overhead wires—and we do not think this will be denied—the greatest danger is from those which are not continually under supervision, and particularly among these are those known as dead wires—that is, which have been used, but for some reason or other have been given up. We quite understand that it is always convenient for the company to disconnect these wires, because it may so happen that within a very short period some other subscriber will enable them to utilise such wires. Still, there remains a good few which have not been used for a considerable length of time. It has been suggested that if the use of overhead wires is to be continued no unused wires should remain *in situ* after the lapse of a certain time, and that the company should be compelled within the limits of this time to take down the wires, and so lessen the probability of accident.

Long-Distance Telephony.—Telephonic communication between Sweden and Norway will soon be established. The funds necessary for carrying out the work were voted by the Governments of the two countries in 1891, but for various reasons the carrying out of the scheme was deferred until this year. From Stockholm the telephone line passes *via* Oerebro, Karlstad, and Kongswinger to Christiania. The line is composed of a double copper wire 3·3 millimetres in diameter, and is suspended from the telegraph posts. It is anticipated that conversation will be rendered easy by the use of this type of wire between the Swedish and the Norwegian metropolis, and with the southern portion of Sweden. On the Swedish ground the line is connected with the State telephone network and with the system of the General Telephone Company, which uses double wires. On the Norwegian side, a public call office has been established at Kongswinger and a special call office at Christiania. A conversation of three minutes' duration between Stockholm and Christiania costs 1s. 10d.; the charge being double for six minutes. Telephonic communication is also about to be started between Sweden and Denmark, and the charge for conversation between Malmo and Copenhagen will be likewise 1s. 10d. per three minutes.

Comparison of Artificial Lights.—A series of comparisons has been made by Mr. C. Feldmann between the light obtained from different artificial sources and daylight. According to his conclusions, artificial light gives the most satisfactory results when under spectroscopic examination it approaches as near as possible daylight in the character of the rays. The arc lamp and the Auer incandescent gaslight are the artificial sources of light that approach sunlight most nearly in nature, but all artificial light has a warmer or more golden tint than daylight. Ordinary gas flames and low-power incandescent electric lamps emit the red and yellow rays in great excess, and are consequently still less satisfactory. The percentage of the total radiation that is received by the eye as light, varies greatly in different sources. It is lowest in the candle and the ordinary gas flame produced with a slit burner; it increases in the argand and regenerative burners, and in the Auer burner it reaches 20 times the percentage of effective radiation in the candle. With incandescent electric lights it is, however, slightly higher; and in the arc light as much as 80 times the proportion of radiation effective for lighting to the total radiation of a candle may be attained. The author suggests that suitable coloured reflectors attached to arc lamps would give a light closely approaching daylight in character.

A New Electric Railway.—This week the members of the Society of German Engineers, at their thirty-fourth annual meeting at Barmen, made an inspection of the mountain electric railway now completed in that town by Messrs. Siemens and Halske. The line is just over a mile long. It connects the centre of the town with the Barmen Wood and the elevated part near the Toelle Tower, and it affords a rapid means of transit towards the local pleasure grounds. The average gradient is 1 in 10, and the most severe is 1 in 5. The line is double throughout, and the gauge is 3ft. 4in. Each car accommodates 36 persons, and is equipped with two electric motors of 36 h.p. The motors actuate gearing which drives pinions gearing into the rack rail laid in the centre of the line. The current is collected from a copper conductor, as in the usual overhead trolley system, and after operating the motors, returns by the rails to the generating station in the town. The dynamos generate at 500 volts, and the overhead conductor is carried on transverse span wires fixed to iron pillars in the town and to wooden posts in the open ground. The cars are provided with three brakes, and there are four stations. The generating station has been designed with a view of dealing with the local supply of motive power, and for the operation of the electric tramways shortly to be constructed in the town.

Mid-African Telegraph.—This telegraph is intended to connect the Cape with Cairo, and contracts have already

been entered into to carry the line as far as Lake Nyassa. The section to the south of the Zambesi is to be made in the territory proper of the British South Africa Company, but the work of constructing the northern section in Nyassaland will be carried on under Mr. H. H. Johnston. The two sections when completed will meet at the point of junction selected upon the Zambesi. The whole length of line, for the construction of which the contracts have been signed, is 400 miles, and, in accordance with the decision to carry on construction from both ends at once, material for 200 miles has been sent to Chinde, while the material for the remaining 200 miles has been sent to Beira. The terminus at the northern end will be Zomba, near Blantyre, where Mr. Johnston has fixed the seat of government for Nyassaland. The line will be carried throughout upon iron poles, and at the point at which it crosses the Zambesi it will be carried to a height at which there will be no chance of the lines interfering with shipping. The work will be carried out in a spirit of the most friendly co-operation with Portugal, and in return for the right of using the already existing Portuguese wires to Quilimane, which establishes a branch connection with the eastern coast, the company will undertake to transmit Portuguese Government messages free of cost over their wires.

Electric Cooking.—The *Pall Mall Gazette* in a short article which savours of padding, and hard work for padding at that, says of electric cooking: "At present electric cooking is a fad. 'Tis true, 'tis pity; but pity 'tis 'tis true. Its merits are much talked about but seldom sampled. A delicate-handed lady will watch the broiling of the afore-mentioned cutlet with curiosity. She will prod it with a fork, and exclaim 'How delightful!' She feels on a sudden that here is something new; something she can show off to her friends in a dainty drawing-room at Bayswater. The absurdity of afternoon cutlets is self-evident, and she buys instead—an electric tea-kettle for occasional use. There is no thought whatever of a clean, convenient, economical method of cooking. No notion of its usefulness, no desire to try it crosses her mind. It is new, and therefore it is *chic*. It is a pretty toy. Yet if everyone would use electric cooking-stoves, or even gas-stoves, what a difference in the matter of fogs it would make to suffering London! Nothing but a course of plagues, followed by the simultaneous asphyxiation of all the firstborn, will ever instil into the breasts of the community such a communal idea as this. Let my neighbours all use smokeless stoves and welcome—each man says—then my one poor little kitchen fire will make no difference. And so say all of us—in London." It would be interesting to know any new departure that was not originally "a fad." It seems to us that many of the generally used notions nowadays were first of all obtained by the luxurious as luxuries, and descended like words from the drawing-room to the kitchen. It may be *chic* to have an electric tea-kettle, but as electric wires ramify from the mansion to the ordinary dwelling-house, so will electric kettles and other such-like paraphernalia.

Underground Telephone Wires in Manchester. The question of placing telephone wires underground in Manchester has not yet been settled. When the members of the City Council met on Wednesday the subject was warmly discussed. The Guardian Society for the Protection of Trade and the Chamber of Commerce had presented resolutions in relation to underground telephone wires. The former represented that the number of overhead wires already in existence had reached a point threatening the public safety. They were consequently of opinion that the time had arrived when all telephonic wires within the city should be laid in conduits underground, the Corporation reserving to itself the exclusive use of such conduits or the leasing thereof on such terms and conditions as it might prescribe; and, further, that in settling such terms and conditions, care should be taken to prevent the service becoming an absolute monopoly. They claimed, first, that the charge should not be more than would be sufficient to yield a reasonable return upon the cost of supplying the service; secondly, that every citizen prepared to pay the fixed charge should be secured in his right to demand the service; and, third, that the service should be constant and continuous. The memorial of the Chamber of Commerce expressed the opinion that it was essential that the Corporation should continue to retain complete control over the public streets. A resolution was moved that negotiations should be opened with the National Telephone Company on the subject of underground wires; but an amendment that, pending the result of certain negotiations at present in progress, and the consideration of the petitions of the Guardian Society and Chamber of Commerce, it was expedient that any action in placing telephone wires underground be postponed, was carried. Thus the matter stands at the present moment.

M. d'Arsonval's Experiments.—The experiments brought to the notice of the French Académie des Sciences by M. d'Arsonval on what he terms autoconduction of the body, have created a vivid interest in electrical circles. They bear on the same field as the celebrated experiments of Tesla. The body, or a part only, is placed in an oscillating magnetic field of very high frequency. This field is produced in the following manner: On a cylinder of insulating material (cardboard, wood, or glass, according to the dimensions of the apparatus) is wound in one or several layers an electric light cable carefully insulated. This constitutes a solenoid, in the interior of which the subject is placed. The solenoid is traversed by the discharge of a condenser rendered oscillating according to the process described in his paper to the Société de Physique (April 20, 1892). As condenser, two to twelve cylindrical Leyden jars are used, arranged in two batteries, connected in cascade, the covered surface being 50cm. high by 20cm. diameter. The charge is effected periodically by a transformer giving about 15,000 volts. This transformer is excited by a Siemens alternator, without iron, capable of giving a maximum of 12 amperes at 350 volts. The frequency is 60 periods per second. Under these conditions the inductive power of the solenoid on any conducting body placed inside it is truly astonishing, as the following experiments show: (1) Into a solenoid of three to five turns of a cable of eight strands of $8mm^2$ is placed a single turn of copper carrying a 100-c.p. lamp requiring three amperes at 100 volts; this lamp is brought to a dazzling brilliancy. (2) A man rounds his arm so as to embrace the solenoid, and takes in each hand one loop of an incandescent lamp. In the circuit formed by his arm a current is generated sufficiently strong to light a lamp taking 0·1 ampere. The resistance of the skin is diminished as much as possible by dipping them into two vessels containing warm salt water.

Consulting.—There is a point about which some consulting engineers are particularly sore. It is that too great generalisation is made in many of the reports that are given to local authorities. We agree that the practice is somewhat dangerous, and may lead to trouble. It is of comparatively little use telling an authority that one system will cost so much less or more than another system. What it wants to know is the system it must use, and the probable cost of that system. Great credit is ofttimes taken that a high-pressure transformer

sub-station system is far and away more economical than a low-pressure system. So perhaps it is in extreme cases; but in other cases there is not a pin to choose between the two as far as economy is concerned, and in other cases the low-pressure has the advantage. Far too great a stress is laid upon initial cost, rather than an accurate account of initial cost plus estimated cost of maintenance being given. Every week almost, if it was necessary, harsh criticisms might be made against the generalisations given in reports which can be proved to be more misleading than fit for acting upon. It is a frailty attributable to human nature that men in doubt like to get corroboration of views expressed; but "too many cooks spoil the broth" is an axiom that has a wide application, and reports upon reports are more likely to do harm than good. No two engineers would do any work in exactly the same way, yet either would do it well; so we still urge the principle of selecting a capable consulting engineer to prepare plans, and not to get report after report upon his performance. There are enough capable men to select from, and either would provide an excellent, economical, and workable scheme. Most of them indeed swear by economy, and thoroughly understand the difference between extra initial cost with cheapness of maintenance and less initial cost with an early ramshackle condition.

Welding Rail Joints.—In the course of a paper read before the American Street Railway Association, Mr. A. J. Moxham gave the results of experiments made at Johnstown, Pa., in the electric welding of very long rails. These experiments were carried out with rails joined solidly and held by heavy fishplates, and they demonstrated that for street rails buried in the ground expansion could be neglected. Subsequently 3,000ft. of line was welded solid, and although the track has been subject to a range of temperature of 30deg., no linear or lateral motion has been observed. This line was laid in May, and the welds were made with a specially-designed Thomson welder. Now, as mentioned in a previous issue, 16 miles of track at Cambridge are being welded. The track has been in constant use for two years, and the welding is being done without disturbing the track or paving, except to remove a few paving blocks at the rail joint. The rail is a heavy girder rail about 8in. deep. The old fishplates are first removed, and the ends of the rails freed from rust and scale by a hand emery-wheel on a flexible shaft and operated by an electric motor. A thin piece of steel of the same shape as the rail section is driven tightly between the rail ends to ensure contact. Then the joint is ready for welding. The current necessary to the operation of the car and plant is taken from the trolley wire over the track. This current is employed directly to propel the car, to operate the derrick by which the welding machine is moved, to run the emery-wheels before mentioned, and to actuate a large dynamotor inside the car. This machine takes the 500-volt direct current of the trolley wire and converts it into an alternating current of 300 volts potential. This alternating current is in turn conducted into a transformer, which reconverts it into a current estimated at four volts and 40,000 amperes. This current is then conducted from the transformer through 1,000 strips of copper to the secondary poles, and through the fishplates and the web of the rail. The forcing of this great current through the plates and rail causes heating sufficient to produce a white welding heat in two or three minutes. The poles in contact with the white-hot fishplates are kept cool by a jacketing of water circulated through pipes. When a welding heat is obtained the pressure is applied by a few revolutions of a hand-wheel, and the fishplates are forced against and cemented to the web of the rail. This pressure is accomplished by a system of levers. The poles of the transformer, the tie plate, and the web of the rail are between the lever jaws. By such an arrangement of levers and screws a small force applied to the hand-wheel exerts a pressure of 400,000lb. at the weld. Under this pressure a perfect union of the pieces is obtained and the welding completed. The current is then cut out, the machine is lifted by the electric derrick, and the operation is repeated at another joint.

Municipal Telephones.—The following is a copy of the application by the Glasgow Town Council to her Majesty's Postmaster-General for a telephone license: "The Lord Provost, Magistrates, and Council beg to apply to the Postmaster-General for the requisite license to empower them to establish a telephone exchange service within the city and Royal burgh of Glasgow. The applicants administer the municipal, police, and sanitary affairs of the city; have the control of the public parks and galleries; are the owners of the street tramways within the city and the suburbs thereof, and have power to work the same; manage the public markets and slaughter-houses, and carry out the Contagious Diseases (Animals) Acts, including the establishment of foreign animals' wharves, in terms of those Acts; as the Glasgow Water Commissioners they control the water supply of the city, and a widely extended area in its vicinity; as Gas Commissioners they have the sole right of manufacturing and supplying gas within the city and the adjacent burghs and districts; and they have also obtained a provisional order constituting them undertakers for the supply of electric light within the city. It is the opinion of the applicants that whenever the carrying on of any undertaking within the city necessitates the opening of streets and interference with drains, sewers, gas and water pipes, the control of such undertaking should be in the hands of the municipality. This opinion has again and again been given effect to by Parliament, not only in special legislation relating to Glasgow and other large towns, but in the general Acts empowering local authorities to establish gas, water, and electric lighting works, and to become owners of street tramways within their jurisdiction. The applicants submit that the principles which have been laid down by parliamentary committees, and by Parliament, with reference to these various matters are equally applicable to the establishment of a municipal telephone service. This view is confirmed by the report recently issued by the General Committee of the House of Lords and House of Commons on Electric Powers (Protective Clauses), one of whose recommendations is: 'The committee are of opinion that it is desirable in every way to facilitate the use of complete insulated metallic circuits for telephones, and for this end they recommend that statutory powers be granted enabling telephone undertakers to lay their wires underground.' The carrying out of this recommendation would place the telephone service in the same position as gas, water, and electric lighting undertakings. A cheap and effective telephone service is now recognised to be an absolute necessity in large business centres such as Glasgow, and the present service within the city does not meet the needs of the community. The service is not an efficient one, and the cost is excessive. It is also to be pointed out that the amenity of the city is being destroyed by the network of overhead wires running in all directions, which are also a source of no inconsiderable danger. The applicants are themselves the municipal authorities of the entire area for which a license is being applied, and consequently no consents under the Treasury minute of 23rd May, 1892, require to be produced."

WESTINGHOUSE DYNAMOS.

The Westinghouse Electric Company, whose name is a household word in the United States with reference to electric light and power, have one of the most complete organisations in the world for the supply of electric installations—from engines right through to lamps. While, of course, the work of the company is greatest in their own country, work of all kind is going on all over the world in the erection of stations, supply of power-transmission plant, transformers, and meters. In the erection of stations there is not so much doing at the present time in Europe by the Westinghouse Company, though, as is known, several large stations—Sardinia-street being the most noticeable—have been equipped. But in England and Europe generally a very large business is being done in transformers and meters—in fact, for meters, we suppose the supply of the Shallenberger meter is one of the largest businesses in England in this kind of apparatus. We saw recently a statement of four days' orders—8th to 12th of

Westinghouse Direct Current Railway Generator

this month—for 450 meters, perhaps rather an exceptional run, but one which serves to indicate the activity of this branch of the electrical business. Transformers also form a large branch of work, as the Westinghouse transformer has a deservedly good name for high efficiency and very small drop in the voltage between high and no load.

We have thought it would be interesting to illustrate a few of the most used types of dynamos and motors of the Westinghouse Company, now so largely employed in central light and power station work. Public attention has been turned to Chicago as the embodiment of American ingenuity and engineering skill. Here the Westinghouse Company shine conspicuously. It was this company that obtained the order for lighting the exhibition, and there are working at Chicago 12 1,000-h.p. generators, besides exciters and other machinery, making a total of some 13,000 h.p. used in driving the Westinghouse dynamos. The illustration shows one of these 1,000-h.p. machines belt-driven. There are six such machines direct coupled to Westinghouse engines, and six others driven by other people's engines by belts. One immense Corliss engine drives two of these latter dynamos, tandem fashion, with a "rider" belt—the largest instance on record of rider belt driving, being 2,000 h.p., transmitted by two belts running on the same engine pulley.

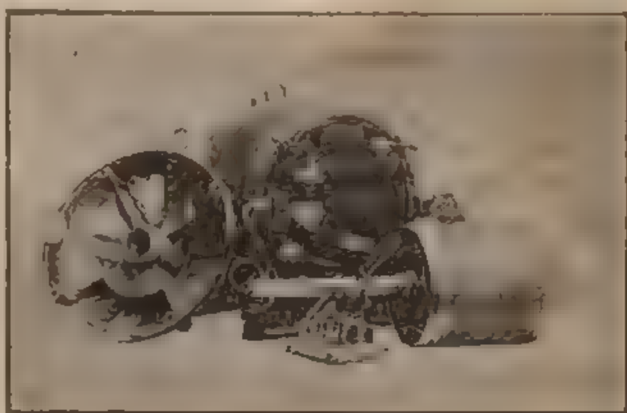
Each of these dynamos is capable of supplying 15,000 lamps of 16 c.p., so that with spare dynamos there are over 150,000 lamps lighted by the Westinghouse Company alone. The armature of these machines is double, in reality being two armatures side by side. It is about 8ft. high, and has very wide bearings. It is driven at 200 revolutions, and gives current at 2,000 volts.

Two Phase Tesla Motor.

These dynamos are all made self-regulating, to give constant potential at any load in a manner somewhat similar to compound windings—that is, by the means of coils whose special function is to increase or decrease the voltage as the load rises or falls. These dynamos are now being made for speeds as slow as 90 revolutions for 2,000 volts.

This Westinghouse alternator is used at Chicago for two-phase currents displaced a quarter of a phase for driving motors and power transmission generally. By a slight rearrangement of the armature on the shaft it will give the usual alternating current.

The switchboards used in conjunction with these dynamos are most magnificent affairs, built of white marble, and fitted with polished metal instruments enclosed in plate-glass frames. All the connections are made below the surface, and no contact can be made or shock obtained by the hands. The connections are made by double plugs fitting into holes making contact behind. In switching, all the connections are made before the current is switched over,



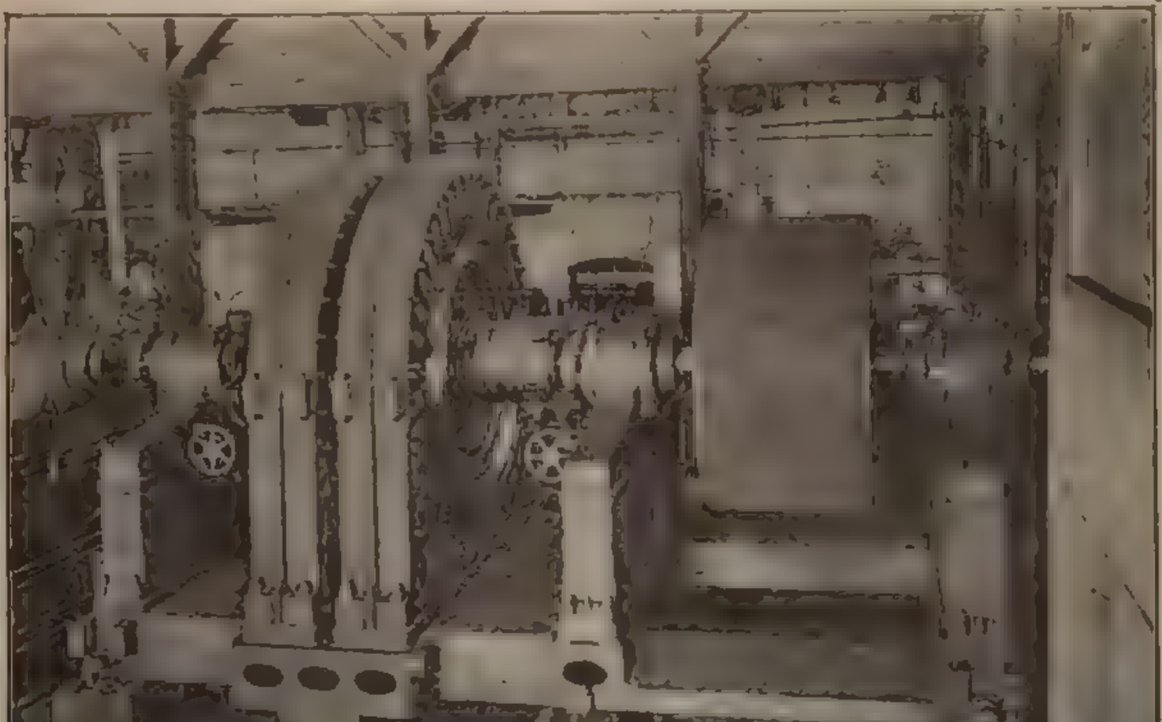
Tesla Motor in Parts.

and only when all the combinations are made and ready is the switch turned. This makes the switching very convenient and very safe. In the great switchboard at Chicago, there are over 1,000 instruments mounted on the white marble slabs.

Although for electric lighting the alternators are most used, for that other great branch of electrical engineering, electric railroads, direct-current generators and motors are, of course, employed. We illustrate one of the standard type of Westinghouse direct-current generators. These are made in four-pole type up to 250 h.p. or so, and to 500 h.p. in the six-pole pattern. Usually, these are compound

wound, with the shunt coils in series, and the four series coils in multiple. The four-pole machines have four carbon-brush holders, the two opposite brushes being cross connected. The six-pole machines have six brushes. These generators are very compact, and when joined to the Westinghouse engine on one bed plate make a most convenient form of railway generator. The company have recently issued a neat instruction book for engineers of railway generators which contains good rules for working such machines. It is to be noticed that fusible cut outs are not used, magnetic contact breakers being now always employed. In these a thick spiral of a turn or two keeps up a double-knife contact switch furnished with two side wings of thick carbon pencil, the latter rubbing against carbon plates. On excess of current passing, the armature is attracted, drops the switch, but the last break is made by the two carbon rods as they leave the carbon plates.

Westinghouse Alternator



1,000 h.p. Westinghouse Alternator used at Chicago.

An interesting engineering feature about all these dynamos and motors is that there is no winding apparent on the surface of the armature. The iron plates are

stamped out, and the coils are usually lathe-wound and slipped into slots on the armature, and then squeezed into shape by a special tool.

Amongst the most interesting of the Westinghouse productions stands the Tesla alternate-current motor. Very great things are expected of this motor, and Mr. Reginald Belfield, the Westinghouse Company's London engineer, at their offices, 32, Victoria street, Westminster, reports that, having seen the alternate current motors of Brown, Oerlikon, and others in Europe, the Westinghouse Tesla motor has proved itself far more practical that any that he has yet seen in Europe. The Tesla motors are made in two general styles—small motors up to 10 h.p. on the simple two-phase system, and large motors up to 500 h.p. or so of a combined alternate current now exhibited for the first time in Chicago. We illustrate the small Tesla motor as it appears in work, and also taken to pieces showing the armature. The motor starts with a very strong torque, and usually starts easily at full load.

It will be remembered that the Westinghouse Company have recently started a 10 000-volt power transmission plant at Pomona for transmission 28 miles, which we have already mentioned. This important installation is on the two-phase system, with the new motors. We think there might be a good deal of such work done in England if any engineer were audacious enough to introduce the two-phase currents, as this system is found better than the three-phase for lighting, and very much more convenient for motors.

Not content, however, with the simple alternate-current system—single-phase or two-phase—the Westinghouse Company are now perfecting a combined system of alternate and direct current distribution which will bid fair to revolutionise present methods. With the combined two-phase machines they can produce not only high-pressure alternating current for transmission and low pressure for lighting, but current for alternate-current motors, and also, by special transforming arrangements, low pressure direct current for charging accumulators, for ordinary motors, or for chemical decomposition. The system holds out great promises for the future. For it can, we think, be said that only when such a complete installation is at work for town supply, and for every purpose that customers can desire, are engineers making the fullest use of all the advantages of a central system of electrical distribution.

THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

LECTURE I.

THE MEASUREMENT OF ALTERNATING CURRENT STRENGTH.

The subject on which I have undertaken to speak to you in this and three succeeding lectures is the practical measurement of alternating electric currents. The limits of time at our disposal will not permit me to deal with the question of electric measurements in general, far less to discuss the elementary principles on which all such measurements depend. I shall take it for granted that you are, at any rate, familiar with the fundamental facts concerning the production of electric currents, and most, if not all of you, familiar with the processes and instruments used in the measurement of continuous or unvarying currents.

The measurement of alternating or periodic currents involves processes and ideas which are somewhat more difficult to master than the simple conceptions which are sufficient to guide us in dealing with unvarying currents. It is towards the elucidation of these special difficulties that these lectures will be directed; and, keeping in view the special requirements of practical engineers dealing with alternating currents, I shall address myself entirely to the practical question of measurement, leaving out of account altogether theoretical matters. The practical measurement of alternating currents is a very important subject, because probably by far the larger portion of the electric lighting of the world is now conducted with alternating currents, and some of the largest schemes of transmission of power that are in process of development or already completed are being carried out by means of alternating currents.

Our first duty will be to begin with some familiar definitions which will make clear the meaning of the terms to be employed. When a conductor is traversed by an electric current we know that certain physical effects are produced. We know nothing about the real nature of an electric current. All that we can do is to measure the degree or amount of the physical effects it produces. Two of these effects are at once evident on very simple investigation—namely, that the current heats the conductor and produces around it a magnetic field. The moment we begin to investigate these effects we find that the electric current may be either in a variable state in which progressive changes are taking place in the effects produced by that current, or it may be a steady or unvarying condition in which the effects remain constant; or it may give evidence of being periodic in its nature—that is to say, the electric current may vary in strength and in direction in a periodic manner. When any cycle of operations takes place in such a way that any given effect runs through a series of changes, we speak of the periodic time of that effect, meaning by that term the time in which the whole cycle of operations is completed. Also we speak of the frequency of the change, meaning by that term the number of cycles completed in a second. A familiar illustration of the use of these terms may be drawn from music. In the case of a musical sound, the string or the air in the pipe runs through a certain cycle of movement, and the periodic time of the note is the time of completion of one complete vibration of the string or of the particles of the air; the frequency is the number of complete vibrations per second. The middle C of the piano has, or may have, a frequency of 256, the octave below that 128, the octave below that 64. In the case of electric currents which are periodic, the strength of the electric current is changing from instant to instant, and it is periodically reversed in direction. Applying the above terms, we speak of the frequency of the current, meaning the number of complete cycles in a second. For instance, the alternating current supplied to this lecture room from Deptford has a frequency of about 84, which corresponds to the lower F on the bass clef. The currents employed in the electric lighting of Rome are about an octave lower—namely, 40 in frequency.

You may picture to yourselves the difference between a continuous and an alternating current as similar to the difference between a non-tidal and a tidal river. In the case of a non-tidal river the waters flow on always in one direction—down the river; but in the case of a tidal river, such as the Thames at London Bridge, the direction of the flow of the water is periodically reversed. When we are dealing with periodic currents or periodic E.M.F.'s, it is very convenient to represent these by means of current curves or E.M.F. curves. To do this we take a horizontal line to represent the periodic time of the current, and dividing this line into a number of small equal parts, we erect perpendiculars at each point, proportional to the strength of the current or to the E.M.F. at that instant; joining the tops of these lines by a curve, we have an E.M.F. or current curve. We then may speak of the instantaneous value of the current or E.M.F., meaning thereby the value it has at any instant, or we may speak of the mean value of the current or E.M.F., meaning thereby the average value which it has during the period. It is also necessary to consider another, a rather more complicated kind of average, which is called the square root of the mean square value. This is obtained by taking the mean of the squares of all the instantaneous values taken at the equidistant intervals during the period, and then taking the square root of this mean value. To avoid constant repetition of this cumbersome phrase, the square root of the mean of the squares of the equidistant values during the period, we shall call it shortly the $\sqrt{\text{mean square}}$ value of the current or E.M.F.

Presently we shall see why it is that certain instruments give us this $\sqrt{\text{mean square}}$ value. It is important, sometimes, to be able to draw these current curves for any alternating current, and this has been done by many observers, notably by Duncan, Ryan, and Hopkinson.

In Fig. 1 we have a diagram of an apparatus used for this purpose by Dr. Hopkinson. On the shaft of an alternator is placed an ebonite disc, having at one point on its circumference a narrow feather of brass laid in. As the ebonite disc is carried round by the machine the brass edge is made to complete the circuit between two metallic brushes, which press against the ebonite disc, and the instant when this occurs can be determined by varying the position of the brushes. By connecting an electrometer with these brushes in the manner shown in Fig. 2, the electrometer gives us the measure by its deflection of the instantaneous value of the E.M.F. of the machine at that one particular instant. By shifting the position of the brushes we can measure the E.M.F. at equidistant intervals during the period, and then plot out the E.M.F. curve. In the same way, by measuring the instantaneous value of the potential difference between the ends of the resistance traversed by an alternating current, we can delineate the form of the current curve for that particular current.

In Fig. 3 are shown E.M.F. and current curves for a particular alternator, and it will be seen that they are highly irregular curves. We have, in the next place, to understand what it is that we are able in general to measure in dealing with alternating currents. When the alternating current flows through a wire, we may, by means of the instrument above described, determine the instantaneous values of that current. But this is not what, in general, we wish to do, neither are we much concerned with the true mean value of that alternating current. In by far the larger number of cases, the only thing that we want to know, and the only thing that we are able to measure, is the $\sqrt{\text{mean square}}$ value above explained.

When an electric current flows through a wire it heats it, and the rate of production of heat is any instant proportional to the square of the current strength. Hence, if the current strength is

* Cantor lectures, delivered before the Society of Arts.

changing from instant to instant, the total quantity of heat produced in the wire in any given time is proportional to the mean of the square of the current strength. Under fixed conditions the temperature which the wire will assume will depend upon this mean square value of the current; for the wire attains its final temperature when there is a balance between the rate at which the heat generated in it and the rate at which the heat has lost by it. The wire loses heat in three ways by convection, by radiation, and by conduction. If a wire is enclosed in a tube in such a way that convection is prevented, then the wire attains a final state of temperature, when there is a balance between the rate at which the wire loses heat by radiation and gains it by internal generation. Under these conditions, the temperature, and therefore the length of the wire, is determined, not by the average, but by the mean square of the current strength. If, therefore, the current is an alternating current, the final temperature, and therefore the length of the wire, enables us to measure this mean square value of the current. In the same way if two conductors, one of which is fixed and the other movable, are traversed by the same electric current, the electro-dynamic repulsion or attraction between these two conductors, due to the

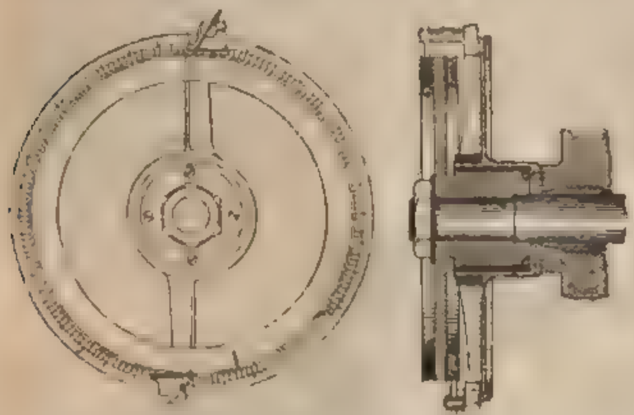


FIG. 1.

magnetic field around them becomes a measure of the same mean square value of the current, for at any instant the stress between the conductors is proportional to the square of the current strength flowing through them, and if the current is varying from moment to moment the average value of this stress is a measure of the mean of the square of the current strength. We may therefore employ either of these two physical effects, the heating of a wire by a current, or the mutual stress between two conductors traversed by the same current, to measure the mean square value of that periodic current.

So much being understood, it is now possible to point out to you what we mean by an alternating current of one ampere. A continuous current of one ampere has been defined by the Board of Trade Committee as an unvarying current of electricity which, when passed through a solution of silver salt, deposits ·001118 grammes of silver per second, or 4·0248 grammes per hour. This may be taken as the practical definition of what is meant by an electrical current having a strength of one ampere when that

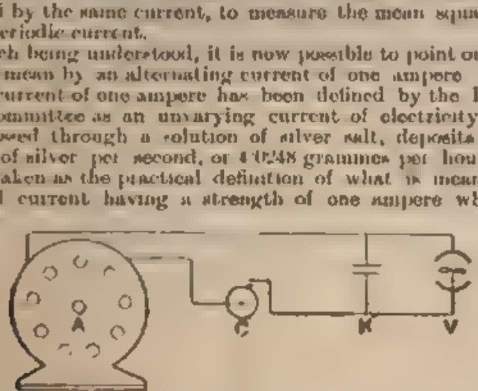


FIG. 2.

current is an unvarying current. An alternating current cannot, however, be estimated by such an electro-chemical method, but it is defined as follows: An alternating current of one ampere is understood to be a periodic current which, when passed through a conductor, brings this conductor to the same final steady temperature as an unvarying current of one ampere would do when passed through it under the same conditions. It is therefore an alternating current whose $\sqrt{}$ mean square value is unity, assuming the instantaneous values to be measured in fractions or multiples of an ampere. Having defined our unit of alternating current, and the two particular general methods of the $\sqrt{}$ mean square value, I may show you two experiments illustrating these facts.

Before me is an instrument which I have designed for some other purposes, but which is practically an apparatus for the measurement of the expansion of a wire. If you look at it you will see it consists of a wooden stand, A B, Fig. 4, having a sliding rod, *a*, at one end, pushed forward by a micrometer screw, M, and at the other end a system of levers, *c*, *d*, *e*, moving a mirror, *m*, from which a ray of light is reflected on to the screen. The micrometer rod and the system of levers are connected by a very fine copper wire, *w*, about 1½in long. On passing a continuous current of electricity through the wire, you see the spot of light on the screen changes its position, indicating that the wire has elongated. I can then, by means of the screw, bring the spot of light back to its old position, and thus measure the elongation of the wire, and therefore its mean temperature. Performing, then, the same experiment with an alternating current which is adjusted to give the same expansion to the wire, I know that I have now passing through the wire an alternating current of which the $\sqrt{}$ mean square value is equal to the value of the continuous current. Such a thermal instrument may be modified in many ways, and we shall presently see the forms it assumes; but in all of them the same principles are, in practice, employed.

In the next place, let me direct your attention to another apparatus, intended to illustrate the electro-dynamometer method of measuring alternating currents. An electro-dynamometer is an instrument which consists of two coils of wire, one of them fixed and the other movable. In the apparatus before you the movable coil is hung up by a steel wire. The movable coil is placed with

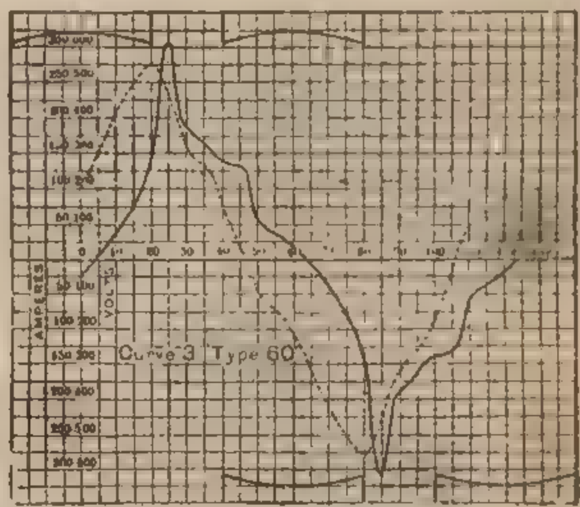


FIG. 3.

its axis at right angles to that of the fixed coil, and when one and the same current is passed through the coils, the movable coil tends to turn round so as to place its axis in line with that of the other; but by twisting round the suspending wire we can bring the coils back to their original position, and this amount of twisting is a measure of the mean square value of the current strength flowing through the coils. If, therefore, the current varies from instant to instant, the force which is required to hold the movable coil in any given position varies as the average of the square of the strength of the periodic current. Hence by means of these instruments, as by means of the hot-wire apparatus, we can measure the mean square value of the periodic current. Whilst I have this instrument before me I will point out one fact which is of practical importance. We know that if a copper plate is held in front of an alternating electromagnet it is repelled, and, similarly, if a copper plate is held near the movable coil of this dynamometer,

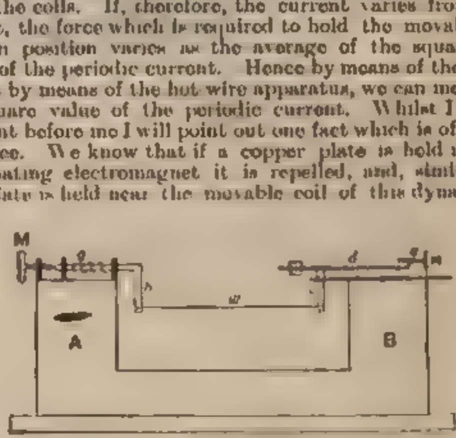


FIG. 4.

it in like manner repels the movable coil when that movable coil is traversed by an alternating current. I shall afterwards have to point out the practical importance of this fact. On the table before me are many different kinds of electro-dynamometers, which have been lent to me by Messrs. Siemens Bros., and you will be able to examine them afterwards; in each case you will see that there is a fixed coil or coils of wire which can be traversed by the current to be measured, and a suspended coil which is also traversed by the same current which passes through the fixed coil. The suspended coil is hung up by a steel spring which resists the movement of the movable coil. When the current passes through the instrument, the movable coil is twisted round, and the amount of torsion which has to be applied to it to bring it back to its original position is the measure of the mean square value of current strength.

Before going on to discuss in detail various classes of practical instruments which depend upon the principles just explained, it may be convenient to give here a brief classification of electric measuring instruments. The table below will show that these instruments may be classified into six divisions, depending on the kind of quantity they are intended to measure. They may also be classified into five species, depending on the particular physical principle which is employed in the instruments. It is not, however, every one of all possible varieties of such instruments that exists. Those instruments which have practically been made are indicated by + in the following table.

—	Electro-dynamic.	Electro-magnetic.	Electro-thermal.	Electro-chemical.	Electro-static.
Ammeters or current meters..	+	+	+		
Voltmeters or pressure meters	+	+	+		+
Ohmmeters or resistance meters		+			
Coloumb meters or quantity meters...				+	
Ergmetersorenergy meters.	+	+			
Wattmeters or power meters......	+	+			·

Taking, then, the first species of instruments—namely, those depending on electro-dynamic force -I will proceed to describe the valuable instruments invented by Lord Kelvin. Broadly speaking, these instruments may be described as electro dynamometers in which there are four fixed coils, around or between which are placed two movable coils attached to a balance arm. Before me on the table are some fine examples of the current balance lent by Messrs. James White and Co. The particular point to notice in these instruments is the manner in which the balance arm which carries the movable coils is suspended, so as to permit the coil to move freely, and will enable us to get the current into and out of the movable coils. Lord Kelvin solved that problem by the highly ingenious arrangement of suspending the balance arm by a large number of very fine copper wires. These flexible ligaments of copper are fixed at one end to a pair of fixed copper trunnions, and the other ends to projecting copper lugs attached to the balance arm. When the balance arm is in equilibrium the movable coils occupy a position between the fixed coils, and the connection of the circuits is such that the current can be passed through the whole of the coils in series. When this current so passes it brings into existence forces of attraction and repulsion between the fixed and movable coils, and the balance arm is tipped over in one direction. Equilibrium can then be restored by moving a sliding weight along a tray attached to the balance arm, and when the balance is obtained the position of this weight can be read by means of a scale. By the principles above explained the force required to hold the beam in its position of equilibrium is proportionally to the square of the current strength, and accordingly the beam can be graduated in such a manner as to read off currents directly. Fig. 5 shows the latest pattern of standard centi ampere balance.

(To be continued.)

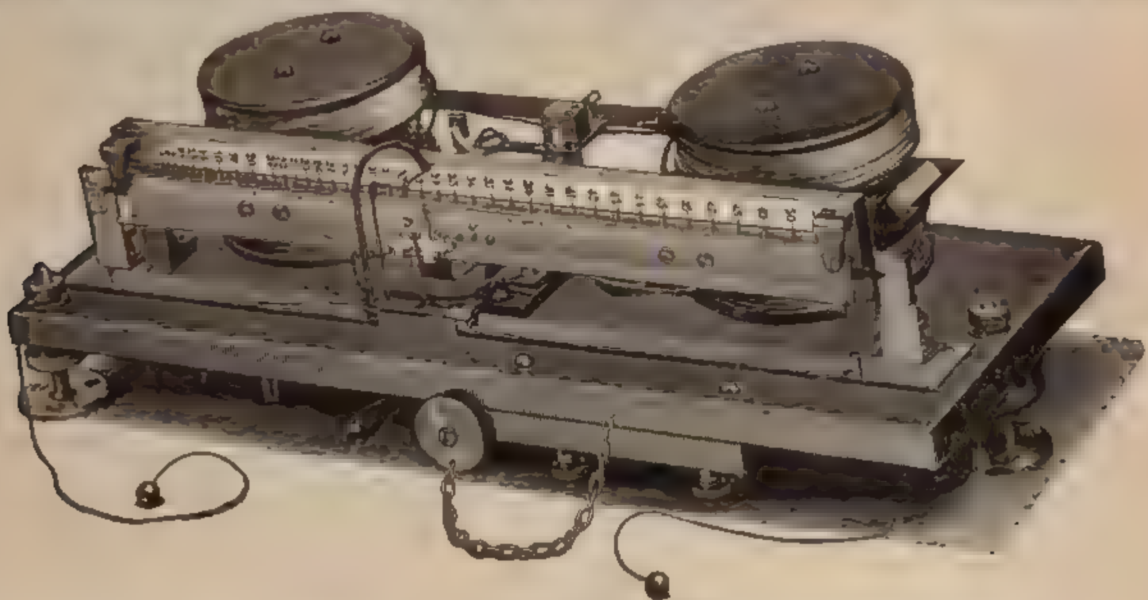


Fig. 5.—Standard Centi-Ampere Balance.

REPORT AND ACCOUNTS OF THE BRUSH CO.

Directors: J. B. Braithwaite, Esq., jun. (of Messrs. Foster and Braithwaite), chairman; Arthur Ayres, Esq., M Inst C.E., Aymor H. Sanderson, Esq., Colonel Frederick George Steuart, B H. Van Tromp, Esq., Edward Woods, Esq. (past president Institution of Civil Engineers). Joint Managers: John S. Raworth, M I E.E., and R. Percy Sellon, M I E.E.

Fourth annual report to be presented to the shareholders at the general meeting of the Company to be held at Cannon street Hotel, E.C., on Thursday, August 24, 1893, at 3 p m.

The profit and loss account shows a gross profit of £50,158. 6s., including the amount brought forward from last account, to which must be added £3,150. 12s. 2d., the balance of premium after payment of expenses arising from the additional preference and ordinary shares issued during the year. After deducting standing charges, maintenance of buildings, plant, and patents, interest on debenture stock, and the whole cost of concentrating the Company's works at Loughborough, amounting to £1,328 11s. 2d., there remains a balance of £26,394. 12s. 9d. to be dealt with. After providing the full dividend on the 6 per cent. preference shares for the year, and an interim dividend at the rate of 5 per cent. per annum, which has already been paid, on the ordinary shares for the half year ended December 31, 1892, the Directors recommend that the whole amount standing to the debit of preliminary expenses account, amounting to £1,575. 2s. 3d., be written off; and that a further dividend at the rate of 7 per cent. per annum be paid on the ordinary shares for the six months ended June 30, 1893, leaving £815. 5s. 3d. to be carried forward. The capital account has been increased during the year by the issue of 15,000 6 per cent. preference shares, and 11,617 ordinary shares, which have been fully subscribed. During the year the sum of £10,681 19s 10d. has been expended on capital account, chiefly in additional plant and buildings at Loughborough, and further extensions of the Company's works there are still in progress. These extensions have been rendered necessary by the increasing volume of central station plant which the Company are being called upon to manufacture. Good progress has been made with the construction of heavy plant for the Bankside station of the City of London Electric Lighting Company, the dynamos for which are each capable of supplying current for 15,000 incandescent lamps of 8 c.p. The first two of these are now delivered, and four more are in course of construction at Loughborough. During the past year the Directors have concluded a satisfactory arrangement with the Otis Elevator Company, of Mansion House-buildings, E.C., for the manufacture, at the Loughborough works, of the elevators and other appliances required by them. In view of the growing demand for electrically-worked lifts, arising from the introduction of electric supply into the leading towns of Great Britain and elsewhere, it is thought that the step which has been taken will prove of increasing advantage to your Company in the future. The home business of the Company generally continues in a healthy state, and the expiry of the Edison master incandescent lamp patent next November will probably give an additional impetus to central station development. Your Directors have made arrangements to resume the sale of incandescent lamps of their own manufacture as soon as the above Edison patent expires. The Australian branch of your business has naturally received a severe check owing to the late financial crisis in the Colonies, but your Company has sustained no loss through any of the bank failures which have taken place. In Austria your business shows a steady growth, and the factory is kept fully employed on continental orders. During the year the municipality of Temesvar has purchased your central station there. The amount thus received has been deducted from the property accounts of your foreign and colonial branches, a separate balance sheet of which is subjoined as usual. The outlook for the current year is good. Your works are at present fully employed and fresh orders are coming in well; whilst in the coming year the full benefit of the economies anticipated from the concentration of the Company's manufacturing operations at Loughborough should now be felt. It is believed that these economies will prove sufficient to provide the dividend upon the last issue of shares. The Directors deeply regret to record the loss by death of the late chairman—the Duke of Marlborough. The active interest he displayed in all questions affecting the electrical industry causes his loss to your Company to be the more keenly felt. Mr. J. B. Braithwaite has been elected chairman in his place. Mr. E. Garcke has resigned his position on the Board and, subject to the confirmation of the shareholders at the general meeting, Mr. Arthur Ayres has been elected to succeed him. Messrs. J. B. Braithwaite and B. H. Van Tromp retire by rotation, and, being legible, offer themselves for re-election. The auditors, Messrs. Cooper Bros. and Co., also retire and offer themselves for re-election.

Balance-sheet, June 30, 1893.

	£.	s.	d.	£.	s.	d.
Authorised capital	750,000	0	0			
Capital issued—viz., 90,000 6 per cent. preference shares of £2 each	180,000	0	0			
90,000 ordinary shares of £3 each	270,000	0	0			
	450,000	0	0			
Less calls unpaid	6,765	0	0			
				443,235	0	0
4½ per cent. perpetual debenture stock				125,000	0	0
Creditors—sundry debtors	35,660	5	2			
Bills payable	5,426	2	7			
				41,086	7	9
Reserve account, as per last account, less £1,550. 3s. 10d. applied during the year				1,529	16	11
Balance of profit and loss account	26,394	12	9			
Less interim dividend paid on preference and ordinary shares	10,500	0	0			
				15,894	12	9
				£626,745	17	5

Note.—Contingent liability in respect of uncalled capital on shares in other companies on guarantee and on bills receivable discounted, £9,429. 13s. 9d.

Cr.	£	s.	d.	£	s.	d.
Property, patents, and goodwill, as per last balance sheet				273,321	7	11
Less written off last year				3,000	0	0
				270,321	7	11
Additions to buildings	4,483	2	5			
Additions to plant	5,422	9	0			
Expenditure on new inventions	776	8	5			
	10,681	19	10			
Less amortisation of leases	733	6	10			
				9,948	13	0
				280,270	0	11
Stock.—Goods in hand in process of manufacture and materials at London, Loughborough, and other places				91,555	11	6
Debtors—sundry accounts	117,645	11	8			
Bills receivable	1,895	6	3			
				119,540	17	11
Cash at bankers and in hand				27,392	8	8
Shares and debentures in other companies				42,731	10	0
Provisional orders account				529	18	2
Preliminary expense, as per last account	2,375	2	3			
Less written off last year	800	0	0			
				1,575	2	3
Liquidator's balances and suspense accounts				1,657	9	10
Balance of foreign and colonial branches accounts, being excess of assets over liabilities				61,492	18	2
				£626,745	17	5

Appropriation Account.

Dr.	£	s.	d.
Further dividend on preference shares at the rate of 6 per cent. per annum, and on ordinary shares at the rate of 7 per cent. per annum	13,504	5	3
Extinction of preliminary expenses	1,575	2	3
Balance carried forward	815	5	3
	£15,894	12	9

Cr.	£	s.	d.
Balance	15,894	12	9
	£15,894	12	9

Profit and Loss Account, June 30, 1893.

Dr.	£	s.	d.
General charges—viz.:			
Directors' fees	1,968	15	0
Auditors' fees	105	0	0
Salaries	7,005	12	10
Staff bonuses	1,732	7	0
Law charges	292	5	0
Insurance	726	11	11
Postage, stationery, and printing	1,007	1	8
Travelling, carriage, and freight	852	0	10
Advertising, agency, and sundries	3,738	4	7
	17,427	18	10
Cost of removal to Loughborough	1,328	11	2
Maintenance of buildings and plant	2,368	4	7
Maintenance of patents	138	13	3
Interest on debenture stock to June 30, 1893, and on 6 per cent. debentures paid off on Dec. 1, 1892	5,650	17	7
Balance, being net profit	26,394	12	9
	£53,308	18	2

Cr.	£	s.	d.
Balance from last account	753	3	6
Premiums on new issue of shares and debentures, less expenses of issue	3,150	12	2
Gross profit	49,405	2	6
	£53,308	18	2

Balance-sheet of the Foreign and Colonial Branches—Being the Balances of the Following Accounts: Vienna (made up to December 31, 1892); Australia (made up to April 30, 1893).

Dr.	£	s.	d.
Creditors—Open accounts and bills payable	57,183	14	11
Unpaid balance of purchase price of land secured by mortgage	7,250	0	0
	64,433	14	11
Balance of assets over liabilities transferred to general balance-sheet	61,492	18	2
	£125,926	13	1

Cr.	£	s.	d.
Property—For freehold and leasehold lands, buildings, plant, tools, fixtures, etc., at Vienna and in Australia	48,215	4	4
Stock—For goods in hand, in process of manufacture and materials	35,692	9	4
Debtors—Sundry accounts (after provision for doubtful debts and bills receivable, including estimated profit to June 30, 1893)	40,581	8	0
Cash at bankers and in hand	1,200	14	8
Shares in other companies	20	0	0
Australian suspense items	216	16	9
	£125,926	13	1

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ACCUMULATOR TRACTION.

Sir,—"My powerful thirst for information" has at last drawn from the Epstein Accumulator Company, through the mouth of their prophet, Mr. Broekman, certain statements which I venture to think, when analysed, will be found to yield a no more valuable marketable commodity than that of froth.

Having satisfactorily proved to the electrical world that traction by Epstein accumulators is, in efficiency, durability, and economy of working, as well as in initial cost, the acme of perfection in their own opinion, *vide* Mr. Epstein's evidence before the Joint Committee and Mr. Broekman's letters, I trust that any remarks of mine in this letter will not dishearten them in trying to develop their system up to the summit of their ambition—viz., ebullition. "The never-failing regularity of accumulator traction" *versus* "the frequent irregularity of the direct system," does not appear to compensate the directors of the Birmingham Central Tramway Company, who, by their balance-sheet, inform us that although the Bristol-road section has a larger earning capacity per car mile than any other part of their system, yet the expenses per car mile are considerably higher than those of horse, cable, or steam traction, each of which they make use of. Of course, Mr. Epstein or his prophet might suggest that this was due to expensive and incompetent management, but as the same management is over each system, it is clear by parity of reasoning that the cost of motive power on the Bristol-road must be the highest.

Before passing to criticise the figures given by Mr. Broekman for the cost of motive power for accumulator traction, I do no more than suggest that any alleged advantages in efficiency must be greatly discounted by the increased weight of car, to which will have to be added the extra cost for wear and tear on the permanent way. I notice that the Epstein Accumulator Company are prepared to stand by the figures they have now given, to work any line at the cost of 3.928d. per car mile. This is to include fuel, oil and waste, brushes on motors, lubrication, wages at charging station, depreciation of buildings, and maintenance of accumulators; but I ask, what has become of car repairs and those necessary but expensive adjuncts to traction, drivers and conductors?

With these additions to Mr. Broekman's figures, it is significant that he is prepared to contract to work electric cars (for motive power only) at a price which is above the total cost of traction on the Leeds electric tramway, and about two-thirds more than the present cost of traction on the Liverpool overhead.—Yours, etc.,

London, S.W., Aug. 15, 1893. Stephen Sellon.

(For remainder of Correspondence see page 157.)

THE

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CONTENTS.

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 Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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THE OUTLOOK.

August is not a bad month to lazily look backwards or forwards, and to contemplate work that has been done or which is likely to be done. Since last year the air has cleared a bit—struggling firms have given up the ghost, and trade is getting on a firmer footing. There is still, however, too much cutting and too much work that is of a flimsy character. Gradually the majority have come to the opinion that to local authorities must we look for the future development of electric lighting and transmission of power. The gas interests are as rampageous as ever, attacking every loose statement, making the most of failures, dragging failures to the front and putting on one side all successes—trying, in fact, their level best to inculcate false notions in the minds of all who attend to their sayings. From most of those who favour gas, electricity has never had fair play, and we who advocate electrical work should recognise this, never allowing statements to pass without pointing out their one-sidedness. But to return to the present position of affairs and the immediate outlook. We have commenced during the past week or two a tabular statement showing the position of municipal electric lighting. This has been done in the interests of business men. The time has long passed when it was possible to keep the position of municipal matters secret, although in the earlier stages of negotiations every attempt is usually made to do so. The awakening of a local authority is often due to the initiative of some contracting firm or supply company, and the negotiations between these parties ought to be held somewhat sacred by competitors. Many a station has been delayed, many an arrangement spoilt by idiotic interference. It would be by no means difficult to pillory men now in active work who have been and are guilty of pushing into places already negotiating with others, promising to carry out the work at an impossible cost and for a smaller than ordinary remuneration. Generally, in the long run, the cost of the work is greater than it would have been in the hands of the original engineer. So much for interference; but there are places where the initiative comes from the local authority, and the matter is open to everybody without fear or favour. The opening of a small or large central station does not mean business only to the extent of the contracts. There is the wiring of houses and factories, the supply of electroliers, of lamps—arc and incandescent. There is, in fact, a new industry opened to the tradesmen of the town, and unless the electrical general factors are asleep, their travellers will soon open accounts in that town and supply the various materials that must be in constant demand. The ironmonger who keeps a stock of chandeliers will soon find it to his interest to keep a stock of electroliers. The big London firms cannot open branches everywhere, and though Edison-Swan may find it advantageous to do so, say, at Manchester, they will most likely prefer an account with a local man at Burton-on-Trent. A local authority, then, taking up electrical work thus

opens a number of doors for orders, and the ramification of the business developed is felt in many a centre of industry. At first the bulk of business may be small, but it increases, and must increase. There is much knowledge to be obtained by the earnest business enquiries that we cannot give—that we, in fact, honestly ought not to give. Take a piece of work at random, say at Nelson. This is a very enterprising, rising, prosperous Lancashire town, envied somewhat by its neighbours because of its rapid prosperity, all its actions watched critically and, if showing the shadow of success, followed. It owns the gasworks, but it also goes in for electrical work, and without a doubt various other towns will follow in its wake. It is not difficult for a business man to find out where these towns are, but it would be impossible for a journalist to give information. He can do nothing till a public sign is made, till the matter is mentioned in council or committee, and then if the business man is not already on the spot and in the swim he has been lax, and ought to find himself outside. The field is not open to suppliers of wire, lamps, fittings, and such-like apparatus till a later period, but it is best not to leave these matters too long, or the field may be found unprofitable. As we are showing in our table, there is a large amount of work under consideration. Plans are already under weigh for several important centres, and the successful opening of one station frequently causes other authorities to come to a definite decision to set to work, so that unless the unforeseen happens, the next year should see a fairly large number of stations commenced and completed. To the unemployed this should prove grateful tidings, for the equipment of these stations will need a certain number of electrical mechanical engineers, and, as we have previously said, the position of electrical engineer to a local authority will become one of the prizes of the profession.

GLOBULAR LIGHTNING.

SIR,—I am sending you an account of what appears to have been a very interesting case of globular lightning, as I am sure it will be of interest to some of your readers. The case referred to occurred at Dunchurch Hall, near Rugby. There had been a severe thunderstorm in the neighbourhood, and about three quarters of an hour after the last flash was seen, what looked like a ball of fire passed obliquely just over the house, struck a tree, which it cut into two pieces, and then exploded with an alarming report. The tree is about 20 yards from the house. Twenty-seven panes of glass were broken, and fragments of wood no larger than an ordinary chip were blown right over the house on to the drive, showing what a violent explosion must have taken place. Photographs of tree, with *débris* scattered about, have been taken.—Yours, etc.,

W. P. STEINTHAL.

32, Clarence-street, Loughborough.

ELECTROLYSIS OF PIPES.

SIR,—In your issue of the 11th inst. you give a note upon electrolysis of pipes, and quote from the *Canadian Architect* a method suggested for the protection of the pipes which to us seems entirely impracticable, on account of the amount of labour and great expense entailed in putting it into effect.

Permit us to point out to you that by coating the pipes with two coats of anti-sulphuric enamel a complete protection is assured. This material is an elastic composition which has been used for this purpose with the greatest success in many instances, as it is not only a perfect insulator, but being unaffected by acids, earth salts, and moisture, is superior to any other material that can be used for the purpose, and entirely dispenses with the covering of tarred hemp and two or three coats of a good hard elastic japan suggested by the *Canadian Architect*.

The "anti-sulphuric enamel" is an elastic composition which can be easily applied, and dries rapidly.—Yours, etc.,

GRIFFITHS BROS. AND CO.

Bermondsey, S.E., Aug. 16, 1893.

ELECTRIC LIGHTING OF LIGHTHOUSES.

In the course of a paper, read recently before the Maritime Congress, on "The Progress of Lighthouses," Mr. D. A. Stevenson, B.Sc., engineer to the Commissioners of Northern Lighthouses, referred as follows to the use of the electric light:

After many trials, the electric light was first exhibited from the South Foreland Lighthouse in December, 1858, the lamp used being that of Duboscq. Various inventors have improved the electric lamp, of whom Staite, Serrin, and Berjot are the chief; and the lamp most generally in use combines the essentials of the two last named. Various powerful machines exist, but it has been found that for lighthouse purposes a magneto-electric machine gives the best results, and that of De Meritens has been introduced at several lighthouses with excellent results.

The optical apparatus used with the electric arc at Dungeness (1862), La Heve (1865), Grisnez (1869), etc., were sixth order. In a report dated November, 1865, Messrs. Stevenson recommended the use of apparatus of the third order, and they further proposed to obtain the proper horizontal and vertical divergence by adopting Mr. T. Stevenson's differential lens suggested in 1860. The South Foreland (1872), Souter Point (1871), Lizard's (1878), are third order; Macquaire (1881), first order Tino (1884), Isle of May (1886), and St. Catherine's (1888) are second order.

There are now five electric lights on the coast of England, and one in Scotland. Between 1863 and 1885 eight electric lights had been established on the coasts of France, and the French authorities are still extending this system.

The relative penetrative powers of gas, oil, and electricity during fog formed the subject of careful photometric enquiry by Mr. H. B. Dixon, at the South Foreland experiments in 1885, and the results arrived at were as follows: "(1) That the oil and gas lights when shown through similar lenses are equally affected by atmospheric variations. (2) That the electric light is absorbed more largely by haze and fog than either the oil light or gas"; but that "in all weathers and at all distances its penetration has proved superior to the gas and oil lights." (3) That "all three are nearly equally affected by rain."

These conclusions have been amply verified in actual practice at lighthouses in Scotland. At midnight at each lighthouse in Scotland the keepers observe the lights which are visible in clear weather from their stations, and record in their journal whether they are visible or not. The following are the results of their records so far as they bear on this question:

	Times per annum.
Isle of May electric light was not seen from St. Abb's, distant 22 miles, on an average of four years	116
St. Abb's oil light was not seen from Isle of May on an average of four years	167
In favour of electric light	51
Isle of May electric light was not seen from Fidra, distant 10 miles, on an average of four years	59
Fidra oil light was not seen from Isle of May on an average of four years	134
In favour of electric light	75

Isle of May electric light was not seen from North Carr lightship, distant seven miles, on an average of four years	21
North Carr lightship was not seen from the Isle of May on an average of three years	135
In favour of electric light	114

St. Abb's Head is a first order eight-sided flashing light, using a five wick paraffin burner—one of the most powerful oil lights in the Northern Lighthouse Service.

The illumination of beacons by electricity conveyed by submarine wires was suggested by Messrs. Stevenson in 1854, and experiments were tried between the chain pier at Trinity and Granton breakwater, a distance of half a mile. The battery consisted of 16 Bunsen cells, and Wilde's electromagnetic machine was also tried. The results were satisfactory, but the experiments were not prosecuted, mainly on the score of cost. This proposal has now been fully realised at Gedney's Channel leading to New York Harbour. The electric station is at Sandy Hook, whence cables are led partly by overhead wires and partly by submarine cables to light six buoys for marking each side of Gedney's Channel, a beacon at Sandy Hook, and three buoys in the main channel. The lights are incandescent lamps of 100 c.p. each, shown from spar buoys about 50ft. in length, and rising 10ft. above the water. The power to work two dynamos is from 8 h.p. to 10 h.p.; normal voltage, 156; normal current, 29 amperes. The cost of the plant has been £2,913, while the maintenance is £683 yearly. The practical result of this better lighting of the approaches to New York Harbour is that the number of ships using it by night per month between 1889 and 1892 has doubled.

In the United States Lighthouse Service, electric lights, combined with dioptric apparatus, have been introduced in lightships. On each of the two masts there are four lanterns "hung on gimballs in brackets permanently fastened to each masthead. In each lantern is a 100 c.p. incandescent light. It is estimated that with the increased power due to the len's lanterns, the four lanterns at each masthead will give a total light equal to 4,000 c.p. Major Heap devised an exceedingly simple apparatus by means of which the lamps are extinguished and lighted automatically at definite intervals. Thus the light has the appearance of a flashing light."

MEANS OF DIMINISHING SPARKING IN CONTINUOUS-CURRENT DYNAMOS.*

BY W. C. RECHNIEWSKI.

We know that even in the best continuous-current machines it is necessary to shift the brushes to prevent sparking when the current varies. That a dynamo shall work well in practice it is necessary not only to find a non-sparking position for each current, but also that this position affords a certain margin on each side so that a small error in the position of the brushes is not prejudicial, and it is also requisite that the current may vary within large limits without necessitating the shifting of the brushes. The ideal would be to have no shifting at all at any load. A good machine may come near to this desideratum; we wish to study the means to achieve it.

There are two quite distinct phases of the problem to distinguish.

Suppose an armature traversed by a current, C; this current enters the circuit by one brush, divides in two, and becomes reunited at the other brush as it leaves the armature. The current in the sections of the armature is therefore C/2, and it changes its direction each time the coil passes the brushes.

1. For each given load of the dynamo there should exist a non-sparking position.

Theoretically, this position is that where, by the sole play of the E.M.F.'s acting on the coil short-circuited by the brush, the current in this coil is reversed and brought to its normal value, C/2, which it will have when the brush leaves the segment of the commutator.

* From *L'Electricien*.

If the brushes are too far back, the current will not have attained, at the moment of breaking the short circuit, the value C/2, which it should have after this; there will, therefore, be a sharp jump accompanied by sparking. If, on the contrary, the brushes are too far forward, the current in the coil will be not only reversed, but its value will exceed the C/2 which it will have after breaking the short circuit; there will, therefore, be a sharp change of current, and, consequently, sparking at the brushes. Figs. 1, 2, and 3 show these three cases. In these figures the abscissæ represent the displacement of the coils under the brushes; the ordinates the currents in the coil. The distance between the vertical lines represent the period during which the coils are in short circuit.

FIG. 1.

Fig. 1 shows the case in which the brushes are too forward, and the current has not attained the value C/2. In Fig. 2 the current has just reached, at the moment of breaking, the value it should have afterwards; while in Fig. 3 it has overstepped this limit. It is evident that Fig. 2 is the best.

FIG. 2.

We must remember that in order to make this position possible, and the same for all coils, the coils must be distributed very uniformly over its surface, and, further, that the difference of magnetic potential between the pole-pieces, expressed in ampere-turns, should be greater than the number of ampere-turns on the armature. These conditions are well known, and we need not further insist thereon.

2. But it is also necessary that the current, C, of the dynamo may vary without change in the position of the brushes; and the greater this variation the better will be the machine.

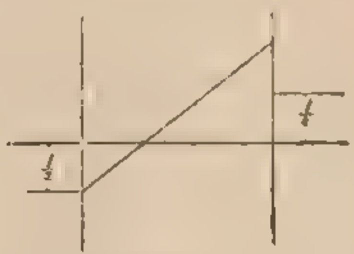


FIG. 3.

In motors, for instance, where the load varies constantly—tramway motors, travelling cranes, machine tools, etc.—the brushes cannot be constantly shifted: it is therefore very important that a great variation of load can be made without dangerous sparking.

Let us consider a position of the brushes which does not give rise to sparking, and let us vary the current. When the current increases, the magnetic field for the short-circuited coil ought to increase, in order that there should be no sparking, whereas, on the contrary, it decreases by reason of the reaction of the armature. The current in the short-circuited coil will not, therefore, have attained the value C/2 at the instant the brushes leave the commutator seg-

ment. At this moment there will be a sharp change of current, and consequently sparking.

The advantage is easily seen of rendering this reaction of the armature as low as possible; that is, of rendering the difference of magnetic potential between the armature and the pole-pieces expressed in ampere-turns as large as possible, relatively to the ampere-turns of the armature. Unfortunately, all sorts of practical considerations are against this, especially the question of price. We have, therefore, to turn to the other factors upon which we can act.

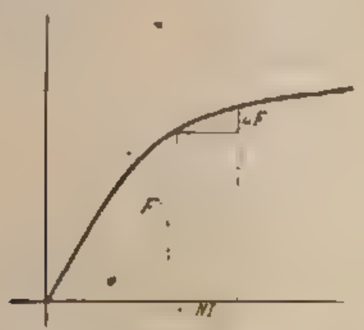


Fig. 4.

Each time the load varies above or below that for which the brushes are set, there will be a sudden change of current in the short-circuited coil at the moment of leaving the brushes. The change of current will be accompanied by a sudden change of flux which will rise to sparking, or a tendency to sparking, at the brushes. We may even say that the sparking will be in direct proportion to the variation of flux.

The problem therefore consists in making this change of flux as small as possible for a given change of current in the section passing under the brushes. To apply the results of the calculation to any machine, we must take the relation between this change of current in the short-circuited coil and the total current in the dynamo. Calling this current C, let us see, for instance, what would be the variation of flux when the current in the coil under the brushes changes from $-\frac{C}{2}$ to $+\frac{C}{2}$; that is, charges by C amperes. Call the number of turns in the coil N, and the variation of ampere-turns will be N C.

F being the flux of the dynamos at the moment considered, it will be easy to see on the characteristic, Fig. 4, to what change of flux, Δ F, the change, N C, in the excitation corresponds.

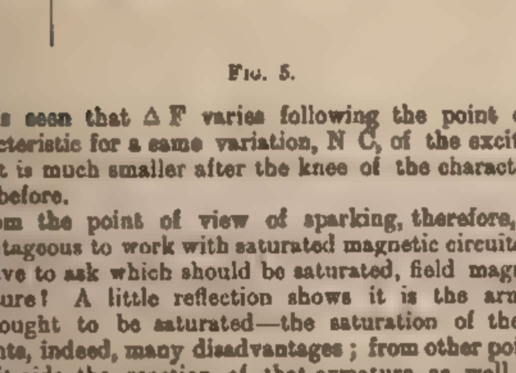


Fig. 5.

It is seen that Δ F varies following the point of the characteristic for a same variation, N C, of the excitation, that it is much smaller after the knee of the characteristic than before.

From the point of view of sparking, therefore, it is advantageous to work with saturated magnetic circuits; but we have to ask which should be saturated, field magnet or armature? A little reflection shows it is the armature that ought to be saturated—the saturation of the field presents, indeed, many disadvantages; from other points of view it aids the reaction of that armature as well as the lowering of the voltage which results therefrom when the load is raised, while saturation of the armature avoids many inconveniences.

It is often said that smooth-surfaced armatures spark less than toothed armatures. This might be true if we worked with armatures not saturated, or very little saturated. In Fig. 5, where *a* represents a characteristic with a toothed armature, and *b* with a smooth armature, this latter is much less steep at its first part before the bend than the curve *a*, because the magnetic resistance of a dynamo with smooth armature is much greater than one with toothed armature; and it is evident that for a change of excitation, N C, the change, Δ F, in the plan is much greater for a toothed armature than for a smooth armature. But matters are entirely changed when the bend of the curve is passed; indeed, once the armature is saturated the inclination of the characteristics becomes the same in the two cases, and consequently the variation of flux, Δ F, causes sparking, and as this state is arrived at much more rapidly with the toothed armature—that is, with less excitation—there is every advantage in employing it.

Instead of saturating the body of the armature, it is usually more advantageous to saturate the teeth themselves. Once the teeth are saturated the armature behaves exactly as if its air-gap had been increased by the height of the teeth—*i.e.*, had become much greater than that of the smooth armature; and as this is achieved with less excitation, there is an advantage in employing saturated teeth.

The figures indicating the tendency to spark will be therefore:

For ring winding in parallel—

$$\alpha \frac{F}{2}\frac{C}{2} = \frac{1}{4}\alpha F C.$$

For winding in series—

$$\alpha\, 2 \frac{F}{2} C = \alpha F C,$$

or four times greater.

For drum winding in parallel—

$$\alpha F \frac{C}{2} = \frac{1}{2}\alpha F C.$$

For drum winding in series—

$$\alpha . 2 F . C = 2 \alpha F C.$$

It is seen, therefore, for large machines, that the Gramme winding in parallel is the best, on the condition, of course, that only one turn per section is used. The combinations of windings which can be made for dynamos with six, eight, or more poles are still more numerous, but it is easy to apply to them the same reasoning.

(To be continued.)

ELECTRIC LIGHTING AT CHELTENHAM.

In our last issue we gave a brief account of the proceedings on the 8th inst. at the meeting of the Town Council of Cheltenham on the occasion of the presentation of the report of the Electric Lighting Committee by Mr. G. Norman, and we now give a more complete report. The minutes comprised an account of an interview between the members of the committee and Mr. Preece, F.R.S., with reference to the scheme for the lighting of Cheltenham. It will be remembered that when the reports sent in by Mr. Hall (the borough surveyor) and Prof. Ayrton, F.R.S., were discussed at a meeting of the Town Council in January last, it was suggested that a further opinion should be taken, and Mr. Preece was called in. The Mayor (Alderman J. C. Griffith) occupied the chair at the interview.

Mr. Preece. I have had just as much experience of the high-pressure system as the low pressure system, and I have recommended the low-pressure system where it is best from the engineering point of view, and I have recommended the high-pressure system where that is best from the engineering point of view. I have read with a great deal of care the reports of Mr. Hall and Prof. Ayrton. I have been over the ground, I have examined the place, and I have got all the information I could within the time at my disposal. I find your compulsory area extends over a considerable distance; I find that your anticipated clients are scattered about very much; and I have the strongest belief that the only satisfactory system which you could introduce here and with which you could give proper financial results is the high-pressure system. The low pressure system would mean that you would require a central station in the central part of the

town, and that you would have to expend a large sum of money in your mains. The high pressure system means that you could place your station anywhere and that you would not have to spend so much money in mains. And here you have special reasons, which I will give you by and by, why the destructor station is eminently and admirably adapted for a central electric light station, and where you could work it with economy on the high pressure system, and where you certainly, because you have the destructor always at work, have an element of considerable economy in the working expenses. I have no doubt whatever as to the system to be introduced here. It must be the high pressure system. The success of a gas industry is an indication of the success of electric lighting. There is no doubt as to the relative merits of the two lights. If you could supply anybody with the electric light at the same price he had to pay for gas, it is certain that people would take the electric light in preference to gas, not only because it has a brilliancy all its own, but because it is so health giving, and does not do the mischief to goods and decorations which gas sometimes does. So I say that by simply looking at the success of the gas industry here, you have an almost certain criterion of the success of your electric lighting industry. But when you come to the town itself, and go through the streets, and see the hotels, shops, Assembly rooms, theatre, Montpelier Gardens, why, long before you decide upon a certain scheme, long before your works are ready, and long before you turn on the current, you will have such a demand for the light that the amount of supply you now contemplate will not be sufficient. I am sure that you will have a return that will pay you very well, and I have no doubt that the prospect of business here is very encouraging. But the fear of most ordinary beings in connection with town councils is that they may have, at any rate for the first year or two, to incur a loss and fall back upon the rates to meet some deficiency. There is not a single instance on record where the electric light has been introduced where there has been any necessity to make a call upon the rates. In every single case where electric lighting has been introduced, the working expenses have been met, even in the first year.

Mr. Steel: Is that correct in regard to Ipswich?

Mr. Preece: The electric light has not been carried out by the Corporation at Ipswich. I am confining my remarks to installations carried out by corporations. There have been a great many companies who have carried out experimental installations which have been failures—cheap and nasty kind of things; but where a corporation has deliberately gone to work out a well-designed installation, or any installation, it has always proved a success, and I have not yet succeeded in finding one single failure.

Alderman Wethered: That does not include cases where the corporation has taken over the works from a company, but where the corporation has started the industry?

Mr. Preece: Yes, where they have started the industry. I mention this in particular, because the argument has been used "We shall have a tremendous loss the first year." Even your engineer, Mr. Hall, expects a loss on the first year. I don't. I think you will succeed in covering your working expenses. I won't go so far as to say that in the first year you will make sufficient to pay interest on the redemption fund; I will only say this, that you will cover your working expenses. You won't incur a loss which will compel you to come upon the rates, and in the second year there is not the slightest question you will clear sufficient to pay interest and to provide a sinking fund as well. So I don't see any reason why anybody should anticipate a loss when you start in a business which will meet your working expenses at the very first start of it. The next point I want to urge is, as to the relative cost of gas and electricity. Mr. Hall mentions electricity at 5d. per unit as equivalent to gas at 3s. 4d. per 1,000ft. I don't agree with that. I think he is on the wrong side. I have taken the mean consumption of all the electric lamps in England for 12 months. They number altogether nearly 900,000 lamps, so that when you take the mean of 900,000 lamps you are not far from the truth; and the mean consumption of those 900,000 lamps for the year 1892 was 18 units per annum. Eighteen units per annum at 6d. per unit means 9s., and therefore the mean cost per electric lamp—that is, a 35-watt lamp of 10 c.p.—is 9s. per annum. I have also taken out the gas returns of gas companies and gas corporations for 1890. I could not get any later returns of gas.

Mr. Woodard: That is street lamps?

Mr. Preece: No, the whole industry. It amounts to many millions of lamps, and it came out that the average consumption of gas per five cubic feet burner was 3,000 cubic feet per annum per gas burner. Well, the mean price of gas throughout the whole country is 3s. per 1,000ft., so that it comes out in this way. The mean consumption of gas being 3,000 cubic feet per burner at 3s. per 1,000, it brings the costs of a 10 c.p. lamp, whether burnt by electricity or gas, at exactly the same amount per annum—namely, 9s. So that I say that gas at 3s. per 1,000ft. is equivalent to electricity at 6d. per unit. Therefore, if you introduce your electricity at 6d. per unit you are introducing a light which is equivalent to gas at 3s. per 1,000ft. That is an argument based upon the behaviour of an enormous number of lamps—900,000 electric lamps and some millions of gas lights. And it is a very broad way of looking at the matter. I rather dwell upon this because it is a favourite thing to say that the electric light costs twice as much as gas. I am a gas shareholder as well as an electrical engineer, and if I were a gas engineer I should say this: Here you have gas giving you 15 c.p., so that five cubic feet would give a light which is equivalent to 15 candles, while your electric light is only 10 candles; therefore my gas is 50 per cent. better than your electric light; but that 15 c.p. is only obtained with great difficulty in the laboratory, with a specially designed sort of burner, great care to check the gas, great care that the pressure is exact, and the chemist or other person who makes the gas has to exercise the greatest care to get the full effect out of 5ft. In practice, if you take an ordinary burner, you will find that instead of it taking five cubic feet to give us your standard of 15 candles, five cubic feet gives only 10 candles. I have also made a series of exhaustive tests, and I can never get 10 c.p. So I say unhesitatingly, that an ordinary electric lamp burning 35 watts—that is a certain definite amount of electricity which is easily measured—gives the same light as an ordinary five cubic feet gas burner, so that the comparison, in making the 35 watt lamp and the five cubic feet gas burner each costing 9s. per annum, is a very fair and accurate comparison to make. But I rather went off the rails. I want to show that the gas engineer in making believe that the electric light is twice as dear as gas, shows the gas which he burns with a gas burner in a condition that it does not come up to the standard of light required by the Act. And then again, they also take into consideration this, that the two lamps are burning exactly the same time. Well, they are not. Most of you have your houses lighted with gas, and I have no doubt your experience is the same as mine. The servant goes round and lights up the whole of the rooms, and unless you exercise a strict supervision they are never turned down until put out. You don't think of turning down the light in the drawing room when you go in to dinner, consequently it burns to waste. With your electric lamp, however, the case is different. You have your switch at the door, and you instinctively get in the habit of turning it off, and instead of burning 600 hours a year, as the average gaslight burns in London, in private houses, and premises of a similar character, the electric light average is only 480 hours. So that you get 50 per cent. difference in the quality of the light and nearly 25 per cent. gain in the number of hours it is burning, and it is these two together which makes the difference. An electrical engineer could prove to you exactly how much you consumed. It really means this—that you must take the whole question in a very broad view. Don't take the figures as being my figures: take the figures of my friends the gas engineers and the gas journals. However, I think you will find my statements are justified. Another point is that the cost of the production of electricity and the working expenses is not a speculation—it is not even an estimate and a calculation, it is an absolute fact within the reach of everyone of us, and those who have had experience, as I have, will tell you to the smallest fraction of a farthing how much electricity costs to manufacture. At the Post Office, where we have 10,000 lamps, the cost of the production of electricity, including the maintenance of the lamps, is 2·45d. per unit. The cost generally in places where the light has been introduced comes out at about 4d. per unit. That is because so much is necessarily expended on mains. In carrying it over the area of a town like this, you have the mains to lay, and a certain amount of energy is lost in the mains, so that if you take it at 4d., which is a very fair average for the whole of the country, I think you are perfectly safe, and therefore you have got 2d. to your advantage if you charge 6d. to your clients. It costs you 4d., and you have 2d. profit, and therefore it comes to this: that the amount of your profit will simply depend upon the number of clients or customers you get. Mr. Hall shows you the cost of working and how many customers you think you may have, and after that it goes to profit. There is one point I should like to urge in connection with this, and that is that the larger your supply the greater the number of your customers, the cheaper per unit is the cost of production; and the longer you keep on the supply the cheaper—it is proportionately cheaper to run it four hours a day than two hours a day. If you can get clients to take the energy for motor purposes during the day you also reduce the cost of electric lighting, and, as I pointed out once, if it were possible to have the supply of electricity during the whole 24 hours—that is, supposing you have any industry that would take it the whole 24 hours—you could produce your electricity at the same price as gas would be at 2d. per 1,000ft. Of course, people cannot conceive gas at 2d. per thousand, but electricity at one third of a penny per unit is the same as gas at 2d. per thousand. There is an industry where the copper used for electric purposes is almost entirely obtained, and where the electricity is produced at a cost of one-third of a penny per unit. This has not convinced many of my gas friends, but it is a simple fact that the larger the production, and the longer the supply is kept on, the cheaper the cost, so that if you succeed in getting a large *clientele*, and if you have long use for the light, your cost would come to less than 4d. per unit, and you would be in a position to reduce the charge per unit to perhaps even less than 5d. The lowest charge at present made is 4½d. There is one other point on which I do not quite agree with your surveyor. I am a great advocate for public lighting, not on a large scale at first, but on a small scale, and lighting the most prominent spaces with the most brilliant and best arc lamps that are in the market. We find that at the Post Office that we get more work out of our men now that we have introduced the light, and that it pays for itself. At the Savings' Bank, where we have 1,500 employés, we have introduced the electric light, and the introduction of the electric light resulted in this—that the number of days' absences through sickness was diminished two days per head per annum, and the consequence was that we got 3,000 more days' work out of our staff in a year than before; and simply putting the cost at the lowest rate, the value of these 3,000 days was £700 odd, and the total cost of the electric light was £680, so that we get our light for nothing.

Mr. Norman: The advantages to be gained by the destructor site will more than compensate for the additional distance the mains will have to be laid as compared with the centre of the town?

Mr. Preece: Certainly, and I wanted to point out this, that one cause of the cost of the production of electricity is due to the fact that during the whole of the night and during the whole of the early morning and part of the daytime you are compelled to keep your current on, and that means a considerable waste of coal and energy. With your destructor there already at work, you have sufficient heat generally there to produce 50 h.p. or 60 h.p., and that is more than you want from, say, after 10 o'clock till 4 o'clock in the afternoon. That destructor will be worth ½d. or ¾d. per unit to you.

Mr. Norman: You have said, Mr. Preece, that you consider, under the circumstances of Cheltenham, that the high-pressure alternating current is the preferable system to adopt?

Mr. Preece: I have no doubt about it.

Mr. Norman: I should like to ask you whether you consider that the method of distribution—namely, that of delivering the high pressure current to transforming stations, and then serving the areas at low pressure—is preferable to placing the transformers at the houses?

Mr. Preece: Yes, to transform in the house would introduce an element of danger.

Mr. Norman: Then you endorse entirely what Prof. Ayrton recommends.

Mr. Preece: Yes, it is the only possible and practical way of carrying out the alternating current system.

Mr. Norman: I think I know your views upon this point. Your opinion is that lighting by electricity ought to be in the hands of the governing body of a town of a large population like this, and not in the hands of a private company?

Mr. Preece: Most distinctly. When it is the hands of a private company you have to deal with promotion money and directors' fees, you have to deal with dividends, and you have to deal with dividends of a much higher character than the interest you have to pay on money borrowed, you have people interested in the industry who might not be in the locality itself, whereas, when a corporation take it into its own hands you borrow money at a very low rate of interest, there is no promotion money to be paid, no directors' fees to pay, you will have all the organisation in your own hands, you have your own officers all there, and you strike away at once. Another element, when in the hands of a company, is the additional expense, and this is a tax upon the ratepayer—this extra expense as between a company and a town council. A company must also establish a sinking fund out of its profits, so that financially, all round, there is not one word to be said in favour of a company as against a corporation. There was something to be said in their favour in the earlier days of electric lighting, or at any rate there was something to be said against risking the ratepayers' money upon experiments; now there are no experiments to be paid for—it is a fixed industry, and if carried on properly is bound to pay.

Mr. Norman: Then there may be developments in the way of lamps and carbons, but do you think it possible that there could be any such improvements in the principle of the machinery, or is there any other factor that would make it desirable to wait?

Mr. Preece: There is practically little or no room for improvement. Machinery is manufactured with an efficiency of 94 per cent. If you get your plant it will give you an efficiency of 94 per cent., which means there is only 6 per cent. to work upon. The transforming parts have an efficiency of 98 per cent., so that there is no room for improvement there. The only place where improvement is coming is in the lamp, and there is little doubt that we shall have great improvement there. The patent for the incandescent lamp expires this year. We are now paying 3s. 9d. each for this lamp. I have already had offers of any number of lamps at 10d. each. The people themselves who hold the monopoly will probably bring their price down to 1s., and we shall get not only lamps whose price has been reduced from 3s. 9d. to 1s., but we shall get lamps supplied to us which will be infinitely better than the present ones. The lamp which you get now consumes four or five watts per candle; we now have offers of lamps to be supplied from Switzerland at 10d., which will give just the same result while consuming only 2½ watts per candle each. Therefore lamps will at the end of the year be obtainable not only at a cost reduced from 3s. 9d. to 1s., but we shall also have lamps giving the same results with an expenditure of only two-thirds of the present power. So that there is room for an immense economy.

Alderman Wethered: I understand you to say that in no case where a corporation has started electric lighting has there been any loss incurred? At Oxford (he believed) there is the low pressure system.

Mr. Preece: No; it is the high pressure system, but it is not the alternating current which they use. They have moving motors of a complicated and expensive character. I think you save yourselves a great deal of trouble by adopting the high-pressure alternating-current system.

Alderman Wethered: And the reason you recommend that system here is because of the scattered area of the town, over which I understand you went yesterday?

Mr. Preece: It is a scattered and an extensive area. It is simply a plain engineering question, and taking the engineering conditions into consideration, it is not a choice between high and low pressure; it is a necessity, not a choice.

Alderman Wethered: Then you believe the electric light is the light of the future, and that it is bound to supersede gas in the near future, and therefore if we were to allow a company to come in we should simply be letting a monopoly come in?

Mr. Preece: Distinctly.

Alderman Wethered: And that by introducing it ourselves we shall be not only saving the rates but preventing the setting up of another monopoly in the town.

Mr. Preece: Yes.

Mr. Norman: I see that in paragraph 21 of your report to the Corporation of Tunbridge Wells you say, "I do not know if ever your Corporation has had to consider the disposal of your own town refuse, but if the formation of a destructor has to be investigated, I think it is well to point out that the combination of a central station for electric lighting with a waste destructor would lead to a considerable economy in the manufacture of electrical energy, and ensure a considerable addition to the profits." That was in January last, so that the advantage of the use of a destructor in this connection was present in your mind before you had anything to do with Cheltenham?

Mr. Preece: I have tried to induce two or three corporations to introduce the light in reference to the destructor, and I think you have here an immense advantage in that you have got your destructor. You have got your shaft, your ground, the amount of money you have to spend upon your building is very small indeed. Mr. Hall does not estimate it at more than £1,600. If you came into the town for a place, you would not build a place for £5,000 that would be fit for a central station, and then you would have to spend another £5,000 on the mains, so that as against the high-pressure system you would have to spend on the low pressure system £10,000 more.

The **Mayor**: You know the town, and that it is divided into different residential districts, and you know the system of lighting proposed to be introduced. Do you think that Cheltenham is a suitable place for the introduction, the successful introduction, of the light, and do you think the measures we propose are wise and sound?

Mr. Preece: I do, most emphatically. I have never seen a town more suitable.

The **Mayor**: On behalf of the Electric Lighting Committee and on behalf of the Corporation, I beg to tender you our most sincere thanks.

At the meeting of the Town Council on the 8th inst., **Mr. Norman**, in proposing the adoption of the report of the Electric Lighting Committee, containing the above account, said its recommendations were as follows: "That the recommendations in Mr. Hall's report be carried out forthwith, reserving for further consideration the method and details of street lighting. That the town clerk do take the necessary steps to obtain the approval of the Board of Trade to the system proposed to be adopted and apply to the Local Government Board for sanction to a loan not exceeding £16,000. And that the surveyor do prepare the necessary specifications on which to obtain tenders for the execution of the works and the supply of the plant and electrical apparatus. The Council is now asked to approve of the proceeding of the committee and of this report." Continuing, he said that upon the opinion which Mr. Preece had given them, he (Mr. Norman) hoped he might challenge the unanimous verdict of the Council. They would see that Mr. Preece confirmed practically upon every point the recommendations of Mr. Hall and Prof. Ayrton. Over and over again he had approved the high pressure alternating system as the most suitable under the circumstances of the town; he had approved the method of transforming at sub stations as the only practical way, and he had approved of the destructor site unreservedly, and said it was likely to effect a saving of from ½d. to ¾d. per unit in the supply. Only on one point had Mr. Preece differed from what he understood the committee to recommend—that of public lighting, but the committee, in fact, had not abandoned the idea of public lighting, and had only postponed a final decision as to the method and detail of carrying it out.

The motion was seconded, and after considerable discussion the report was adopted, with one dissentient.

At the conclusion of the business of the Council a letter was read from the Brush Electrical Engineering Company, Limited, asking if the Corporation proposed to give effect to the provisional electric lighting order obtained by them, as, if not, it was the intention of the company to take steps to secure powers to enable them to undertake the supply of electricity throughout the borough of Cheltenham by means of a local company.

The town clerk was instructed to reply, informing the company of the resolution just arrived at.

BRADFORD.

Notes of Interview on Wednesday, July 19, 1893, between the Gas and Electricity Supply Committee and Lord Kelvin, as to Mode of Extension of Electricity Works and Mains.

Present: Alderman Frederick Priestman (in the chair), the Worshipful the Mayor (William Oddy, Esq.), Alderman Watmough, Councillor Kay (deputy chairman of committee), and Councillors Benn, Crossland, Freeman, J. Greenwood, North, Parker, Shaftoe, Toothill, L. Walker, and Watson.

The **Chairman** stated the reasons for which the interview had been arranged, and asked if the committee wished that Mr. Shoolbred and Mr. Baynes should be called into the room. It was decided that these gentlemen should be present at the interview.

The **Chairman**, after introducing Lord Kelvin to the committee, made a brief statement as to the erection of the present electrical installation, and pointed out that Bradford was the first municipal corporation to commence the supply of electricity to the public. The committee at the outset took great pains to get what, so far as they could see, was the best system. Mr. Shoolbred was appointed engineer at the time, and Dr. Hop-

kinson was called in to advise. The committee then felt justified in starting operations on the system which was adopted, though somewhat against Dr. Hopkinson's opinion. The doctor had then, as he has now, patents on the three-wire system, but it was decided to commence with the two-wire continuous current system. It was always kept in mind and was well understood that it might be advisable at some time in the future to adopt the three-wire system. Up to the present no hitch has arisen in connection with the supply, except that last winter the cables were overcharged with current beyond their capacity, and the light given off by the lamps was thus slightly impaired. As the season is so far advanced the committee came to the conclusion merely at the present moment to supplement the system by the expenditure of about £2,500 on additional plant. Mr. Baynes had expressed the wish that in the future he should be the electrical engineer, and acting under the instructions of the committee had prepared a report as to the proposed extensions. Mr. Shoolbred had also, in accordance with similar instructions, prepared a report on the subject. To judge between these two reports the committee had decided to call in an eminent scientist, and with that view the advice of Lord Kelvin had been sought. The view of the committee was not so much that either of the two reports before them should be adopted, but rather to be assured whether or not they were on the right track in what they had done and what they proposed to do. The committee would not have thought of asking Lord Kelvin's views on so small a matter as the spending of £2,500 or so, but as they are looking into the future, say, for the next 10 or 15 years, they wish to do now what will be found to be the best. The committee desired Lord Kelvin to say how far they have been right up to the present, and also what will be the best course for the future. His lordship had been shown over the works, and with the explanations which had been given to him would have a good knowledge of what had been done, and what the probable requirements of the town were likely to be. He would be glad to answer any questions his lordship might like to ask, and enquired whether he wished to make any additions to or observations on the report he had already presented.

Lord Kelvin, in reply to the Chairman, said he had already made a report, and that all he wished to add to it was as to the distance at which any second generating station might be placed from the present station. He had said $1\frac{1}{2}$ miles, and would like to say it should not be more than $1\frac{1}{2}$ miles from the present station, and might be nearer with advantage if found economical. That was the only point he cared to expand on at present.

The Chairman, having asked the committee what course they would adopt in their present enquiry, was deputed by the committee to ask of Lord Kelvin a series of questions which the Chairman stated he had prepared.

Councillor L. Walker hoped that that would not debar any member of the committee from asking any questions they thought fit to put.

The **Chairman** said certainly not. The committee wanted all the information they could get, and every member was requested to ask such questions as he considered necessary.

The Chairman thereupon proceeded to submit his enquiries, and they were dealt with as follows:

Lord Kelvin, in reply to the Chairman's question as to whether if Mr. Baynes's plan were adopted the committee would have to pay royalty on Dr. Hopkinson's patents, said that a royalty would probably have to be paid on the three-wire portion of the system. He could not say what would be the case as to royalty if the third wire were not brought back to the station, but if the wire were not brought back the working would not be so convenient.

Councillor Kay wished to know how much weight of cable was laid down, to which **Mr. Baynes** replied about 80 tons as cables exist at present.

Lord Kelvin, in reply to the Chairman, said the adoption of five-wire would not avoid royalty having to be paid, as by that system the return wires would have to be carried back to the dynamo. His lordship did not think the five-wire system impracticable or inadvisable in all cases, but in this case he would prefer the three-wire. If thought advisable afterwards, when experience had been gained, five-wire could be adopted. The five-wire was in use in Manchester, but if Bradford were starting *de novo* he would still advise three-wire as had been done. The committee had acted rightly in adopting the present system at the commencement of their undertaking. The possibility of adopting the three-wire system at a future time was fully considered when the works were at first laid down. The three-wire system would at that time have been premature with the comparatively small demand for the electric light then to be provided for. All that is known now was known then.

The **Chairman** said that apparently Lord Kelvin meant that if the three-wire were adopted now it could afterwards be converted, if thought advisable, to the five-wire. If the three-wire were adopted, would his lordship advise alternating or continuous current to be used?

Councillor Kay would like to know Lord Kelvin's views on that point in the event of the committee being able to get power from the Nidd water scheme.

Lord Kelvin said continuous current was undoubtedly preferable, even in high tension (say, 2,000 volts). If Bradford could get cheap power from some distance away, as suggested by Councillor Kay, even at four miles, from the new Nidd water supply, it might be advantageous to use alternating current, but he would prefer even then high-tension continuous current. Alternating currents were a success when a transformer was in use at each separate premises, but the use of transformers involved difficulties which did not arise with continuous current. The latter is better where there are varied requirements, as for charging accumulators, driving motors, electro-plating, etc. The alternating current is more difficult to transmit in large quantity than continuous current. Alternating motors were not yet well adapted for practical use. Asked what he would consider the best and most economical voltage if the new station were in operation, his lordship said that with such lamps as were at present in use he would recommend 250 volts, say 100 or 110 for houses, and 250 at the station.

The **Chairman** stated that the present voltage was 112, and asked if it would be advisable to change it in extending the operations.

Lord Kelvin thought it would not be advisable at present to alter the voltage supplied to the ordinary users. But any large user who would be content to have all his lights in pairs, lighted and extinguished together, might have 200 or 210 volts, and no third wire.

The **Chairman** asked if the potential would have to be raised, or the dynamos rewound or run in series.

Lord Kelvin said that in adopting the three-wire system he would prefer to run the dynamos in series at about 125 volts each, rather than rewind them for 250 volts each, but any additional dynamo which would be required should give 250 volts. The Board of Trade would now sanction 500 volts, but he considered 250 at the station best in present circumstances and for the future until lamps of higher voltage can be had economically.

The **Chairman** said that that completed his list of prepared questions as to future extensions, and asked if the committee wished to give Mr. Shoolbred the opportunity of making any remarks he wished upon the reports.

Councillor L. Walker thought that Mr. Shoolbred should not say anything.

The **Chairman** thought the object of the committee ought to be to get the best possible information in the matter, no matter from whom it was obtained. Mr. Shoolbred was thereupon requested to ask any questions he thought fit on the reports.

Mr. Shoolbred said he wished to draw the committee's attention to a letter he had sent to the town clerk as to alleged irregularities in regard to the placing of the reports before Lord Kelvin. He said that alterations and discrepancies had occurred, and he thought they ought to be explained to his lordship. He wished to say nothing of a personal nature, but objected to the introduction of fresh matter into the reports after they had been before the committee. He quoted from Lord Kelvin's report to show that the new matter had been supplied by Mr. Baynes after the reports were sent up to his lordship.

The **Chairman** objected to Mr. Shoolbred's remarks. The reports ought certainly to have contained the best possible information up to the latest possible moment. He understood, however, from Lord Kelvin, that Mr. Baynes's report mentioned all the points which his lordship would advise the committee to adopt.

Mr. Shoolbred stated that Manchester was not the only place where the five-wire system was applied, and he handed in a list of 15 electricity stations on the Continent where three-wire and five-wire systems were in use, having an output of over 20,000 h.p. The Chairman read particulars from the list.

Lord Kelvin remarked that the additional matter in Mr. Baynes's report to which Mr. Shoolbred took exception was merely supplied to elucidate certain points arising in the conference on the reports, and was promised by Mr. Baynes in Mr. Shoolbred's presence.

Councillor Shaftoe asked if three-wire system would be as economical as the present system.

Lord Kelvin said it would be more economical to adopt three-wire system, even including royalty, which was only a comparatively trifling matter. He could not say with certainty whether the patent would or would not be renewed on expiration two years hence. He considered that when the present works were started, five years ago, the committee had adopted the best system at the time in use. The three-wire at that time would have been of doubtful utility for practical use, and would have required more costly plant. Westminster had commenced on two-wire system and converted since to three-wire. This was not undoing any work, but simply extending their system. Taking all things into consideration, the Bradford Corporation did the best thing they could do at the time, although the three-wire system was in use before the Bradford works started, but was advisedly not adopted.

The **Chairman** said that if the three-wire system had been adopted in the first instance its greater cost would have simply killed the prospects of electricity in Bradford. From the very first the possibility of adopting the three-wire system at some time in the future had been fully borne in mind.

Mr. Shoolbred said that Leamington was the only place using three-wire when Bradford started their works.

Councillor Kay said that St. James's and Pall Mall started in May, 1889, and Bradford in September, 1889, but in reply it was stated that the scheme for Bradford had been settled before those dates.

The **Chairman** asked whether Lord Kelvin considered the short-stroke Willans type of engine or the Corliss type to be the best.

Lord Kelvin said that Willans or similar engines were certainly preferable to Corliss or similar type of engines which ran at slow speeds, with belt-driven or rope-driven dynamos.

Councillor Kay made enquiry as to the cost of coal per horse-power, and also as to gas engines with Dowson's gas plant.

Lord Kelvin could not say anything off hand as to coal consumption. As to gas engines, it might be advisable to make full enquiries, though he would scarcely advise decidedly their use on

his present knowledge. The fact that gas engines dispensed with boilers was one great advantage in their favour.

On **Councillor Benn** asking what disadvantages were found in Corliss type engines, his **Lordship** said they took up too much room. The work at present so well done in the Bradford supply station would be impossible in the same space with large slow speed engines and dynamos driven from them by ropes or belts. Willans and similar engines were also good in that with them each engine and dynamo started together. Willans engines have stood the test of many years use, and proved very economical. For non condensing engines Willans's in many cases are quite as economical as others.

The **Chairman** said that Mr. John Waugh was at Willans's works testing the new engine, and would also test the present engines at Bradford on his return.

Lord Kelvin said that Willans could at any time add another cylinder to their non condensing engines and make them into condensing.

In answer to Councillor Kay, his **Lordship** said that, given the number of units sold and the number of pounds of coal used in a year, it would be a difficult matter to tell the rate of consumption in proportion to true mechanical efficiency of the several engines. The number of electric units produced by the steam engines in the station is necessarily greater, considerably, than the number sold; the coal consumed in the station is of necessity much greater than what would be required to supply, in steady continuous work of 10 hours a day, the electric energy actually produced in the 24 hours.

The **Chairman**: Will you kindly say what you think of the Willans engines as compared with other types?

Lord Kelvin: The experience at electric lighting stations is very strongly in favour of Willans's. Kennedy finds them very good. The Metropolitan Company likes Willans's. The City of London Company uses engines similar in respect to speed and direct driving, though not by the same makers.

Councillor Kay said he had seen a report by Prof. Kennedy in which he strongly advocated the use of gas-engines, say, of 100 h.p.

Lord Kelvin said it was certainly one good point about gas engines that they could be started at once, without waiting to get up steam in case of sudden darkness. Air condensers had been tried, but not, he believed, with much success.

The **Chairman** enquired if it would be advisable to get the engines triplicated instead of sticking to compound. The cost of coal is now ¼ of 1d. for each unit we sell. The coal is little better than smudge, only costing 8s. 4d. per ton, whilst much better coal is used when making tests of engines to ascertain efficiency.

Lord Kelvin thought it probably not advisable, but it would be better to ask engine makers' opinions on that point.

The **Chairman** enquired as to boilers. In putting new ones down would it be advisable to run, say, at 180lb. (the present pressure is 140lb.) and tone down pressure to 140lb. when the boilers begin to age, working them out to feed the original engines which are built for the lower pressure?

Lord Kelvin said 180lb. would certainly be more economical than 140lb. He did not think that expenses for machinery repairs would be much larger owing to the higher pressure, but engine makers should be consulted.

The **Chairman** said that the station had been designed so as to admit of being four folded. Would it be advisable to place boilers on the upper floor?

Lord Kelvin said that that was done at Edison's great station in New York. It was not impracticable, but its advisability would depend on local circumstances, such as the ease with which coal could be got to the upper floor for use under the boilers there.

Mr. Baynes thought that in the above case moist steam would get into the cylinders, but his **Lordship** did not think that would be found a serious difficulty.

The **Chairman** asked what was the best kind of boiler to use. Those in use at present are Lancashire boilers with Galloway tubes. Also a small Babcock and Wilcox boiler but the latter primes easily and smokes a good deal.

Lord Kelvin thought that coke might be used for the Babcock boiler, which is good for rapidly getting up steam; but in other respects Lancashire boilers are preferable.

Councillor L. Walker thought that if Lord Kelvin recommended gas engines it would be advisable to put one down at once.

Lord Kelvin thought it would be wise to do so if on enquiry it were found to answer well elsewhere. In answer to the Chairman as to putting down gas plant or sticking to steam engines, his lordship thought it might possibly be best to stick to steam in the present station. But even in the present station a gas engine might possibly find a place advantageously with special view to sudden requirements, as in the case of a fog coming on suddenly. Gas might be used more largely at any new station, if found economical, as well as convenient.

Councillor Kay said that Dowson's gas could be made at Mill-street and brought down in a 3in. pipe.

Lord Kelvin, in answer to the Chairman, said he knew of no better dynamo than those the Bradford electric station had from Siemens's English firm. There was a German Siemens's firm, also. Messrs. Clark and Muirhead, and the Electric Construction Company, also made dynamos as good as the best. He knew nothing of Holmes's dynamos as yet. English made dynamos are quite as good as the best foreign make. Many English dynamos were, he believed, as good as Siemens's, which were certainly very good.

The **Chairman** enquired as to cables. Which was preferable – bare copper conductors or the ordinary sheathed cable? (Sample of cable at present used in Bradford was produced.)

Lord Kelvin said the present cable was very good, but the bare copper was better where circumstances allowed. It depended largely on the amount of piping, etc., already occupying the streets. With three wire system he would prefer culverts, if not much more costly.

Mr. Shoolbred explained that bare copper strips in culverts would be dearer than the underground cables as at present laid – that is, in the first instance. The culvert was of course preferable if expense be disregarded.

The **Chairman** asked whether, speaking broadly, his lordship would advise putting in culverts, or laying on the old system.

Lord Kelvin said he would go to the expense of culverts if not much in excess of the other. In Glasgow iron culverts were supplied under Kennedy. Irrespective of cost, the culvert was best.

The **Chairman**: If we found cables best at present would you recommend putting in culverts if the cost were double that at present?

Lord Kelvin said that taking into account all expense, the system of bare copper on insulators in culverts should not cost so much as double; indeed, for conductors above a certain size it costs not more than armoured cables, and actually less than armoured cables for the largest of the electric light conductors hitherto laid in towns. The bare copper strip cost less than insulated wire strand in the first instance, and lasts longer than may be expected of armoured cable laid in the ground. As to use of bitumen blocks, he should not think them better than the present system in Bradford, where the cables are laid in ashes. As to laying in iron pipes, there is no objection if the cable is well insulated and strongly enough protected against abrasion. The Bradford cables require more of mechanical protection than if laid in iron pipes, and this is supplied by the armour sheathing. As to cables, his lordship considered that the Silvertown cables were as good as Siemens's, and the British Insulated Wire Company's cables were good if the water could be kept out. The latter cable, although new, and not long tried as yet, is already very well spoken of. In it the insulator is of paper, encased in lead.

The **Chairman** next asked advice as to meters. As the next best after Lord Kelvin's own meter, which did his lordship think should be used for consumers?

Lord Kelvin would not say that his own meter was the best. Meters had presented much difficulty to the supply companies. He knew a case where two lamps could be used all night without the meter showing it at all. The Edison electrolytic meter was too troublesome. As to station meters, he thought it very proper to have a station meter on each dynamo to show how much work is delivered, and would recommend for this purpose either his own meter or that of Edmondson and Oulton, of which he had seen several specimens to day on trial at their Bradford station.

The **Chairman** asked about storage batteries. Which was best?

Lord Kelvin said a certain amount of storage power ought to be at any central station as a reserve. The E.P.S. battery is suited for steady work, but not where there are sudden great calls on the system. The Crompton Howell battery is better adapted for that purpose than the ordinary E.P.S. is. There may be other good batteries, but the Crompton Howell had been judged to be the best for electric supply stations up to the present.

The **Chairman** having asked if it were advisable to add to the present batteries, **Mr. Baynes** explained that the Bradford batteries only sufficed for one side of the third wire.

Lord Kelvin said it would certainly be useful to have an additional storage battery so that the whole voltage required for the three wire system might be had direct from a 250 volt battery. The plan of having the motor generator which he had referred to would allow the station to go on for a considerable part of the 24 hours, at a small rate of supply to users, with only the present battery without engines at all. The expense of a motor generator is small as compared with that of a fresh storage battery. His lordship added, I think it advisable to try a motor generator instead of going to any additional expense at present on storage batteries. Later it may be found, and no doubt will be found, that the storage capacity of the batteries is insufficient. But in view of the great cost of an additional battery I think it advisable to take for the present, and for some time to come, the motor generator. If superseded from its first purpose, the motor-generator could be converted into a steam generator. In view of the expenditure as at present proposed of so small a sum as £2,500, it is not advisable to think of additional batteries. It would be judicious to try the motor generator as recommended by Mr. Baynes. In cases also in which you may wish to run with only one steam dynamo, of 150 volts, this motor-generator would allow you to do so, on the three wire system.

Mr. Baynes said the motor generators he had recommended would have a capacity of 100 amperes each.

As to the charge for electricity to consumers, the **Chairman** said that the present price per unit was 5d. Would his lordship advise a reduction to 3d. or so for motive power during the day?

Lord Kelvin thought it was very desirable to reduce the price per unit to the users of motors during the daytime; 4d. per unit would induce many consumers, and 3d. would fetch more still.

Mr. Baynes thought it would not be a loss to supply at 3d. per unit for motors during the day, as the present cost for coal was only four tenths of a penny per unit.

Lord Kelvin thought the additional expenses involved in giving a day supply would be comparatively small, and if the daily supply were taken up, would justify the reduction in price, which would be for motive power only.

The **Chairman** stated that the present maximum output of the works was 4,800 amperes, and the demand last winter was 4,500 amperes, and he said the committee had had a considerable number

of applications for current this summer. Would Lord Kelvin think it safe or prudent to put any additional consumers on when the engines are now overloaded?

Lord Kelvin thought it would be imprudent to try to increase the output with the present plant. The breakdown even of a small engine would be a disaster, and power ought always to be kept in reserve for emergencies, so as to be able to switch it on at once.

Mr. Baynes, in reply to Councillor L. Walker, said there had been no expensive repairs in the engines. The most costly at any time had been about £12 in amount.

Lord Kelvin, in reply to the Chairman, said he would strongly advise the putting down at once of additional engine power at the present station. He would advise the putting down of a new steam dynamo at 250 volts, and of 300 h.p., which would provide considerable reserve power. He would rather have one of 300 h.p. than two of 150 h.p. each. A duplicate armature would be required for the new engine as at present.

Councillor L. Walker wished to know if Lord Kelvin distinctly recommended Willans engines, to which his **Lordship** said that, all things considered, he would recommend them, though there are other engines, similar in type, about as good. Willans engines have been proved to be good ones.

Councillor Kay asked whether, if Willans engines used 6lb. to 8lb. of coal per horse power, Lord Kelvin would consider them economical? **Lord Kelvin** replied, No.

The **Chairman** said that the town was at present a complete network of mains. If rats got to the cable they could cause a serious leakage, which was difficult to localise. In reply to a question in the matter,

Lord Kelvin said he thought it would be well to divide the town into cable districts so as to minimise the risk from leakages.

Mr. Shoolbred said the town had been originally so divided into sections by him.

Councillor L. Walker again asked if Lord Kelvin thought Willans engines the very best the committee could get, as he wished to be perfectly clear about the matter, to which he attached much importance.

Lord Kelvin replied that so far as he knew Willans engine was the one to be chosen, but he would not say that no other engine was as good. So far as can be judged at present, it is the best for the purpose.

Councillor L. Walker asked whether electricity was likely to be cheapened within the next five years, and **Lord Kelvin** said he thought it probable that that would be the case, and that the committee might be able to put the price at less than 5d. per unit with advantage all round. He was not sure whether the committee by acting on his present advice would cheapen the cost of electricity, but he thought that by enlarging the output by the use of the three wire system, and by making a larger market for the supply, it might be cheapened.

Councillor L. Walker wished to know whether electrical science had not made advances since Bradford commenced operations, and if so, how the present works could be improved. **Lord Kelvin** replied that except as to the application of the three wire system there could be no better arrangement for the present area than was adopted five years ago. There has been no advance in electrical science during the last four years which would warrant any other change from the present system than that now contemplated.

His **Lordship** said that if the committee did their work well and tried to extend their system that was about all they could do. He certainly thought that electricity would be cheaper within the next five years. Five years ago there were dynamos delivering 90 per cent. of the power put into them. Now there are dynamos giving out 95 per cent. Ordinary good dynamos, he thought, would give about 90 per cent. There is not much improvement to be made there, but the opportunity may arise of getting power cheaper. Willans engines, or other high speed direct driving engines, if condensing, will give cheaper power. There is practically no way of decreasing very much the cost to the consumer except by increasing the market.

Councillor L. Walker observed that the supply of electricity would not be very extensively used until it is as cheap as gas, and asked whether there is any likelihood of it being supplied at the same price as gas light for light.

The **Chairman** said he was surprised to hear Councillor Walker say so. If the electric light were generally adopted in the town, what about the gasworks with their £600,000 capital?

Lord Kelvin thought the prices of gas and electricity were not far apart even now. Fivepence per unit compared very favourably with the price of gas in many towns. Even if it cost double the price of gas in a town like Bradford, where gas is very cheap, light for light, many people would gladly pay the extra money, and could even then effect an economy, as the light when not wanted need not be left burning like gas, and it is much more cleanly, and far better for health. It did not injure the stock in shops, nor walls, ceilings, furniture, decorations, etc., in private houses, and there were many other advantages arising from the use of it.

Councillor L. Walker wished to know whether, if the works were started *de novo*, the current could be supplied cheaper than at present.

Lord Kelvin said he believed it could be supplied cheaper to-day if the committee wished to do so irrespective of the question of profit above bare interest on outlay, but he did not think they could have done better on the whole than they had done from the very outset.

Councillor Parker asked if his lordship would advocate the extension of the electricity supply on the ground of public health.

Lord Kelvin replied that it certainly was much more healthy than other kinds of light.

In reply to Councillor Kay's question, if we get 90 per cent. of energy from the dynamos, where does the other 10 per cent. go? his **Lordship** said it was all spent in heat; a small part by mechanical friction, the rest by heating on account of electric currents in the armature and in the electromagnets. The best dynamos gave about 90 per cent. of perfect efficiency.

Mr. Shoolbred doubted whether the new dynamo should be one of 300 h.p. He would prefer two, each of 150 h.p., as tending to more economical working.

Lord Kelvin thought that might possibly be true. It would depend on the requirements at the station. His reason for saying one of 300 was that he thought there were enough of small engines at the place for effecting the requisite changes in output. It depends to some degree on the amount of load likely to arise suddenly.

Councillor Kay asked about duplicate armatures for the fresh engines, if they were to choose them of 150 h.p. each.

Lord Kelvin said one duplicate would do for two dynamos of the same size.

Mr. Baynes said he would advise working the 150 h.p. engines up to 200 h.p., which was the usual practice elsewhere: the saving by the additional output would pay for the spare armature referred to by Councillor Kay.

Mr. Shoolbred said that the so-called 150 h.p. engines would give off 200 h.p. each if required.

Lord Kelvin asked what prospect there was of going a good distance from the present works with the supply, say, to two or three miles away.

The **Chairman** said there was a desire to have the light for houses of the better class at Manningham. We have also to buy gas for some of the out districts of the borough. Up to the present, power has not been got for supplying those out districts with gas by the Corporation, and it has been suggested to supply them with electricity. In the plans the committee adopted five years ago, the borough was mapped out into districts so that stations might be provided for any desired quarter. The nearest point of Manningham from the present station was about three quarters of a mile, and the furthest about $1\frac{1}{2}$ miles.

Lord Kelvin said that when the present station is quite filled up another one should be provided for Manningham at some spot where ground was cheap. This would not involve much more cost than having the requisite additional engines, boilers, etc., at the present station. No separate electrical staff would be wanted, but only good engine drivers, stokers, etc. The full capacity of the present station will eventually be taken up by the centre of the town.

Councillor Watson asked if a new station would be wanted if it were decided to supply Manningham, and the **Chairman** said he thought it would be advisable to put one down.

Lord Kelvin said that the nearer the station could be brought to its work, the more economical it would prove. The proposed plan is not the throwing over of the original plan, but only an extension.

Councillor J. Greenwood wanted to know whether if there were a good supply of water at Allerton, and a turbine were put down, the current could be supplied at less than 5d. per unit.

Mr. Baynes said that the present cost of generating electricity by steam, after paying expenses, including interest and sinking fund, was 1·10d. per unit.

Lord Kelvin said that if the water power could be got at a much less cost than that of steam it would then undoubtedly be cheaper. Much expense would also be saved not only in coal, but also in wages of stokers, etc., which would probably knock more than 1d. off the 5d. per unit. His lordship added that with regard to extensions in other districts it would be wise to go on as far as reasonably possible, supplying at first from the present station, and then, when a growing demand has been established, to erect additional stations as found necessary.

Councillor L. Walker asked Lord Kelvin how long he thought the extensions would take to complete them—that is, the extensions now in progress?

Lord Kelvin could not say, as much would depend on the builder and otherwise, but he hoped they would be finished in good time for the winter requirements.

COMPANIES' MEETINGS.

INTERNATIONAL ELECTRIC SUBWAY COMPANY.

The first ordinary general meeting of this Company was held at 72, Bishopsgate-street Within on the 10th inst., Mr. John L. Martin being in the chair.

The Secretary having read the notice convening the meeting,

The **Chairman** said since the statutory meeting held last year, two contracts for supplying the Johnstone system of conduits have been carried out—one for the City of London Electric Lighting Company, Limited, who laid about a quarter of a mile of the conduit in Blackfriars. The types used were the nine way and the six way, each duct or way measuring $2\frac{1}{4}$in. square. It will be readily understood that as this was the first time of laying the conduit in England, it was a most important moment for this Company. It is, therefore, a matter for congratulation that the work done was perfectly satisfactory, the top and bottom troughs exactly fitting together, and when the conduit was keyed up it made a solid structure. It may be mentioned that no skilled

labour is required and no special tools for laying the conduit; in fact, a great deal of the work can be done by boys, and in this way the cost of laying is much less than where separate pipes are used. Each pipe would cost 6d per yard run to lay and joint, whereas 9d per yard run covers the cost of laying and jointing the nine way conduit. Some of the conduit has also been supplied to the Keswick Electric Lighting Company, Limited: their engineer was so pleased with the system that during the last few days he has ordered some more, with handholes for making house connections. During the last month we have obtained the contract for all the electrical mains at Portsmouth. The types used will be a three way and a two way; each duct will measure 2½in. square, and the house connections will be made by means of the handholes, which are a special feature of this system. The amount of the contract is £12,000, exclusive of accessories, and the work will be commenced in about a fortnight's time. It is most important that the system is to be laid in a well known town like Portsmouth, for there its many advantages will be seen and understood in a way which is impossible where only a short piece of work is done. The Company still owns the patents for France, Austria, Belgium, and Italy, as it has not been thought advisable to dispose of these until a large contract has been obtained in England. Negotiations are now being entered into for working some of the foreign patents on a royalty. The Chairman concluded by moving the adoption of the report and statement of accounts.

The motion was seconded and carried unanimously. A cordial vote of thanks was passed to the Directors, and to the managing director, Mr. Margesson, for the zeal he had shown in promoting the interests of the Company, after which the proceedings terminated.

BIRMINGHAM CENTRAL TRAMWAYS COMPANY.

The annual meeting was held on Wednesday at the Queen's Hotel, Birmingham. Mr. J. Ebbsmith (chairman) presided, and the other directors present were Messrs. W. J. Carruthers Wain, M. J. Smith, and W. Weale.

The **Chairman**, in moving the adoption of the report and statement of accounts, said he was sorry to say the Corporation charges, which were referred to last year, had again shown an unpleasant increase; he meant the charges for maintenance of permanent way, and not the charges for rental under the lease. As the meeting were aware, a committee was formed to approach the Corporation on that subject. The Corporation, as they had a perfectly legal right to do, held them to the letter of their bond, and therefore they had to look to an increase of the traffic rather than to any diminution of those charges. In other words, they must spread the average. The question how that should be done was one of very grave anxiety to them all. They were all aware of the view he had taken. He had examined the accounts, and found that upon the steam lines 30 per cent. only of their receipts went into their pockets as working profits, even that being subject to deductions on revenue account. On the other hand, he saw that under the cable working 50 per cent. of the receipts went into their hands as profit. He was also aware of the fact that the steam lines were not uniform. Some were much heavier and more difficult to work than others, and he questioned whether that 30 per cent. must not be largely decreased on certain lines of heavy gradient and traffic. The shareholders would have observed that affairs on the Bristol-road had materially improved during the past year, but they had not improved to the extent which, in his opinion, they were capable of. One of the difficulties they had to encounter was this. They would recollect that two years ago they went to Parliament for certain additional powers with regard to those lines. They were opposed by the telephone company, who required the most stringent provisions to be inserted in that order; provisions which would not only have tied them down with regard to that particular route, but would have tied them down with regard to the whole of the lines in Birmingham outside that route. Reluctantly, therefore, they withdrew the order. Since that time the telephone company had been seeking to put their trammels not merely around them, but all over the country the telephone company had opposed every Tramway Bill and order which had come before Parliament, and ultimately they themselves introduced a Bill making a general law of those special provisions which they had sought to impress upon particular companies. That Bill was referred to a Joint Committee of the two Houses, and was considered by them at very great length with the best scientific information which could be had before them; and the conclusion of that committee had been not merely to lift from the tramway companies generally those restrictions which the telephone company sought to place upon them, but with regard to the particular system adopted on the Bristol road they declared that the telephone company had no *locus standi* whatever. Therefore the Central Tramways Company was encouraged to proceed with the negotiations which had been held in suspense, and which the Board, after careful consideration by the engineers, were encouraged to believe would mean a profit to the Company upon that line of not less than £2,000 per annum. That was a matter of great satisfaction to them.

Mr. Martyn J. Smith seconded the resolution.

Mr. Greenhalgh said he found that from 1891 to 1893 there had been a continual increase in the expenses of management, and he could not see from the balance sheet that there had been any reason why that should be incurred. Take the item of wages—and he was one who liked to see good wages paid where they were deserved—they paid for wages in the unfortunate electrical department in 1891 £2,572 odd. In 1892, without any great increase in the traffic, the amount paid in wages went up by close upon 80 per cent., and this, in spite of the fact, too, that there was only an increase of about 10 miles in the total number of miles run. The gross cost of the general management of the electric trams in 1891 was £5,711, but in 1893, with the same amount of traffic, the expenses ran up enormously.

The **Chairman** pointed out that the Bristol road route was only opened for nine months in 1891 and he thought Mr. Greenhalgh had overlooked that fact in his calculations.

Mr. Greenhalgh replied that that did not affect his contention. The number of miles run in 1891 were practically the same as in 1893, and the cost of the line in 1891 was £5,711, as compared with £9,721 in 1893.

The **Chairman** said Mr. Greenhalgh had rubbed the salt a little deep into the sore which he (the chairman) certainly did feel with regard to the Bristol road line, and his only reply could be that whatever errors had been committed in the past he was doing his best, by effecting economies and alterations, to turn that line into a profit.

The motion for the adoption of the report was then put and carried, with one dissentient. Resolutions were also passed authorising the payment of a 5 per cent. dividend on the guaranteed shares, and of 2½ per cent. on the ordinary stock. The concluding business was the election of directors, upon which the proceedings were a little protracted.

CUBA SUBMARINE TELEGRAPH COMPANY.

The forty fourth ordinary general meeting was held on Wednesday at 58, Old Broad street, under the presidency of Mr. Thomas Greenwood.

In moving the adoption of the report and accounts, the **Chairman** stated that there had been an improvement in the traffic receipts of over £600 as compared with the June half of 1892, while the working expenses had been less by £562. There was, therefore, an improvement in their position of £1,164, which went to swell the balance carried forward to next half year. The reserve made this half year was precisely similar in amount to that made a year ago, but this time it had been divided, £1,500 being transferred to a reserve against any loss that might arise from the failures of banks in which the Company had deposits, and £5,500 being carried to the general reserve fund; whereas a year ago the whole £7,000 was carried to the credit of the reserve fund only. He did not think they would make any great loss by the bank failures; but the half year was sufficiently good to make the provision which he had mentioned. The charge for the annual payment on account of the purchase of the cable laid in 1881 between Cienfuegos and Batabano no longer appeared in the accounts, for the payment had been completed, and the property now belonged to the Company.

The motion was seconded by **Mr. Charles W. Parish**, and was carried unanimously; and dividends were afterwards declared at the rate of 10 per cent. per annum on the preference shares and 8 per cent. on the ordinary shares.

COMPANIES' REPORTS.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY.

Directors: William Addison, Esq. (chairman), B. St. John Ackers, Esq., Henry Grewing, Esq., Thomas Lloyd, Esq., George Bland Frost, Esq. Secretary: Alexr. B. Chalmers, Esq.

Report of the Directors for the year ended December 31, 1892, to be presented at the thirteenth ordinary general meeting of the Company to be held at the Cannon street Hotel, E.C., on Wednesday, August 23, 1893 at 1 p.m.

As mentioned to the shareholders at the last annual general meeting, an appeal was lodged by Mr. Ness against the decision of Mr. Justice Kekewich in the matter of the declaration and distribution of the previous dividend. The Court of Appeal having reversed the judgment of Mr. Justice Kekewich, the Directors had no alternative but to submit the case to the House of Lords for a final interpretation of the agreement with the vendors. The annual meeting has consequently been delayed pending the result of this appeal. Judgment was given by the House of Lords on the 27th ult., which allowed the appeal, and upheld the decision of Mr. Justice Kekewich. The dividends therefore falling to the vendor shareholders have to be paid over to the ordinary shareholders until such time as the arrears of interest due to the latter for the first five years after the incorporation of the Company have been satisfied. These arrears, after payment of the last dividend, amounted to about £13,000. The revenue account for the year shows a balance to credit of £9,085. 5s. 11d., which has been transferred to profit and loss, and including £1,957. 16s. 4d. brought forward from 1891, there remains a balance for disposal of £11,043. 2s. 3d. The Directors propose to deal with this as follows: to write off £251. 13s. 6d. for legal expenses; £77. 10s. 4d., being 50 per cent. of the Company's claim on the liquidators of the New Oriental Bank Corporation in respect of a balance at Mauritius; £533. 15s. 4d. in reduction of capital expenditure; to transfer £2,500 to reserve; and to pay a dividend at the rate of 2½ per cent. on the total paid up capital of the Company, free of income tax, carrying forward £3,191. 10s. 10d. This dividend, together with that declared on the vendors' shares and applied to the ordinary shares, amounts to £3. 12s. 2d. per cent. on all ordinary shares issued prior to February 4, 1886. Although the balance of revenue account

shows but a small improvement over the previous year, there has been a considerable extension of business at every agency, including those of the subsidiary companies. The remittances and dividends, however, received from the East are, with the exception of Egypt, the equivalent of a silver currency, and but for the further decline in the value of that metal during the year, the revenue account would have shown a more favourable result. The Bengal Company has paid a dividend of 6 per cent., and the Bombay Company one of 4 per cent. for the past year, the last named company again applying 10,000 rupees to reserve and depreciation instead of increasing its dividend. Notwithstanding that the directors of the Telephone Company of Egypt report that one of the late officials of that company had been guilty of grave irregularities, they have been able after payment of debenture interest, to distribute the usual dividend of 8 per cent. on the preferred shares, to write off £426 7s. 4d. for depreciation, and to carry forward £1,446. 7s. The China and Japan Telephone Company closed its accounts for the past year with a surplus on revenue account of £519 15s. 7d. after payment of debenture interest; the directors of that company, however, in view of currency contingencies did not recommend a dividend, but applied the amount in part towards the reduction of capital expenditure and depreciation of stores, carrying forward the balance. The Court has finally approved the amendment of the Company's memorandum of association as sanctioned by the shareholders, and the name of the Company is now registered as the Oriental Telephone and Electric Company, Limited. The directors to retire at the present meeting are Messrs. G. B. Frost and B. St. John Ackers, both of whom, being eligible, offer themselves for re-election. The auditors of the Company, Messrs. Deloitte, Dever, Griffiths, and Co., also retire, and offer themselves for re-election.

BUSINESS NOTES.

Burnley.—A search light is to be fixed in some prominent position in the town.

Romford.—The Board of Health object to telephone poles being placed in any part of Romford.

Scarborough.—The general post office is to be connected by telegraph with the South Cliff post office.

Western and Brazilian Telegraph Company.—The receipts for the week ended August 12 were £2,354.

Taunton.—The Town Council have received sanction to borrow £15,000 for the purchase and extension of the electric light works.

Blackpool.—The work of constructing the central station of the Corporation is slowly progressing. Most of the machinery and accessories has, however, arrived.

Bolton.—Tenders are invited by the county borough of Bolton, as will be seen by our advertisement columns, for the supply and fixing of alternating current transformers.

Brush Electrical Engineering Company.—The directors recommend a half-yearly dividend at the rate of 7 per cent. per annum on both the preference and the ordinary shares.

Personal.—The Watch Committee of the Liverpool Town Council have appointed Mr. W. C. P. M'Muldrow as electric inspector for the city, in the place of Mr. Sherman, who has resigned.

Liverpool.—Complete courses of instruction by the University College of Liverpool are arranged in civil, mechanical, and electrical engineering. Further particulars are given in our advertisement pages.

Coatbridge.—The Town Council have adopted a recommendation of the Electric Light Committee to light the Municipal Buildings by electricity supplied by the House-to-House Electricity Company.

City and South London Railway Company.—The receipts for the week ending August 13 were £826, against £721 for the same period last year, or an increase of £105. The total receipts for the second half-year of 1893 show an increase of £390 over those for the corresponding period of 1892.

Edinburgh.—On Monday, at a meeting of the Edinburgh and Leith Gas Commission some discussion took place with regard to the terms on which the Commission would supply gas to the Edinburgh Corporation for driving their electric light plant. It was agreed to treat the Corporation on the same footing with other large consumers.

Gosport.—The Roads and Works Committee of the Gosport and Alverstoke Local Board have recommended, and the Board have adopted, the recommendation that the application of Messrs. Bromwich and Angove, the solicitors to the electric tramway company, for the Board's approval to their application for extension of time be granted.

Spain.—An assistant electrical engineer is required for Madrid by the Electricity Supply Company for Spain, of 15, St. Helen's-place, E.C. Applicants must be able to go out at once. The salary will not exceed £200 per annum, and applicants must have had experience of high-tension alternating current stations. Letters to be sent to the secretary as above.

Dewsbury.—At a meeting on the 10th inst. of the Town Council, a letter was read from the Board of Trade forwarding copy of regulations and conditions for securing the safety of the public and for ensuring a sufficient and proper supply of energy, which the Board propose to make under the Dewsbury electric lighting order. The regulations were approved.

Brechin.—Mr. Jamieson has given notice to the Police Commission that at the next meeting he would move that an electric light installation, sufficient both for the new police office and free library, should be erected at the former, and that the Watching, Lighting, and Fire-engines Committee be empowered to get specifications drawn up by an electrical engineer.

Fleetwood.—At the monthly meeting of the Improvement Commissioners it was decided to permit Messrs. Andrews and Preece, Limited, of Bradford, and Messrs. Greenwood and Batley, of Leeds, to supply complete tenders for electric lighting in the district. The clerk reported that the Board of Trade had extended the limit of time in the Fleetwood Electric Lighting Order, 1890, to October 20, 1893.

S. J. Claye, Limited.—This Company has been registered by Gears, Son, and Pease, with a capital of £100,000 in £10 shares, to acquire as a going concern the business of railway rolling stock manufacturer and coal and coke merchant now carried on by the trustees of the late S. J. Claye at the Manor House Works, Long Eaton, and at Derby, and to carry on business as mechanical and electrical engineers.

Telephone Wires.—Mr. A. Morley, replying to Captain Bagot in the House of Commons stated that the powers to place telephone wires or tubes underground, either in London or other towns, are regulated by statute, and are in all cases subject to the consent of the local authorities, with an appeal in certain cases to a police or stipendiary magistrate or county court judge, and a further appeal to the Railway Commissioners.

Overhead Wires.—In the case of John Hart *v.* the National Telephone Company, which came on for assessment of damages in the County of London Sheriffs' Court, Holborn, the plaintiff recovered £195 compensation for personal injuries sustained through the falling of an overhead wire upon him while driving with his son in York-road, Wandsworth. In a second action, brought by the son, judgment was entered by consent in his favour for £60 and costs.

West Bromwich.—A memorial is being prepared for presentation to the Yardley surveyors seeking for facilities for the placing of the Acock's Green and Yardley districts in communication with the National Telephone Company's system. The project of the establishment of an exchange at Acock's Green was entertained about two years ago, but a number of residents objected, under the impression that it would injure the neighbourhood. A different view is now believed to prevail.

Craiginches Engineering Works.—These new works, which belong to Messrs. Harper, Limited, have just been equipped with the electric light. There are installed 35 arc lamps, energised from a dynamo giving 100 amperes at 260 volts. The dynamo is driven by a large Tangye gas engine, which assists a duplicate engine to drive the main shafting for the whole works. The installation is the largest of the kind in Scotland. It has been erected by Mr. F. Heppert, of London. The offices are also lighted by 35 incandescent lamps.

Bandon.—Mr. C. Crowley (chairman), presiding at the monthly meeting of the Town Commissioners, said that the motion for refusing consent to the granting of a provisional order by the Board of Trade might be passed that day. There was a lot made about the company because he happened to have a share in it. The matter had been submitted to a meeting of the ratepayers, and the majority authorised the Commissioners to negative the proposal, and he did not see why they could not do it that day. Ultimately the matter was adjourned to the next meeting.

The Bankside Station.—Mr. Leoline A. Edward, of 19, Laurence Pountney-lane, E.C., informs us that he has received from the Brush Electrical Engineering Company an order to supply and fix one of his patent circular furnace coking stokers. It is to be applied to a Babcock and Wilcox boiler at the Bankside station of the City of London Electric Lighting Company. It will be somewhat of a novelty in this country, as although many of these stokers have been fitted up on the Continent, not one is yet working here, although scores of them are in use on Lancashire boilers.

Harrogate.—The sub-committee of the Town Council appointed to consider electric lighting recommended at a meeting on Monday that the Council should carry out the electric lighting order, that Mr. Wilkinson should be appointed electrical engineer to the Corporation, and that Mr. Wilkinson should be instructed to work out the details of a scheme on the basis of the report presented to the committee. It had been previously decided to advertise for tenders from companies willing to supply the electric light. A long discussion took place as to whether it would be advisable to hand the matter over to a private company, but the matter was adjourned for a week to a special meeting of the Council.

Yeadon.—The Local Board have considered a scheme for lighting the township by electricity, and which had been submitted by Messrs. Andrews and Preece, Limited, of Bradford. The project comprised the supply of 1,500 8-c.p. lamps, the cost of which, exclusive of land, buildings, and foundations, they put down at £3,500. The members of the Board were favourably impressed with the scheme, and in order that the Board should be first in the field it was resolved to make application to the Board of Trade for a license empowering them to undertake the supply of electricity. It was further resolved to pay a visit to the Morecambe Electric Light Works, which have been fitted up by Messrs. Andrews and Preece.

London Metallurgical Company.—On Tuesday meetings of the creditors and shareholders of the London Metallurgical Company,

Limited, were held before Mr A. S. Culley, official receiver. In November, 1892, the Company promoted the Areas Plating Company, with a capital of £80,000, to acquire the patent for £40,000, and the business was carried on until the property was taken possession of by a debenture holder. The accounts show total liabilities £17,896 (unsecured £11,830), assets £10,900, and a deficiency of £12,896 to the contributors. No resolution was carried at the meeting of the creditors, owing to an equal division of opinion; but the shareholders elected the official receiver to act as liquidator on their behalf.

Two Waters (Herts.).—An electric light installation has been put up at the works of the British Paper Company, Limited, Frogmore Mill, Two Waters. The work has been carried out by the London and Lancashire Electric and General Engineering Company, Limited, of Kingsland-green, Dalston, N.E. The generator consists of a shunt wound, slow speed dynamo, giving about 60 amperes at 65 volts. The dynamo is arranged so that it can be driven either by steam or water power. The lamps, 43 in number, are arranged on four circuits, each of which can be separately controlled from the main switchboard. An arc lamp of 2,000 nominal candle power is fixed in the Beater House, and is intended for use in colour testing at night time.

Telephony at Rotherham.—A meeting of subscribers to the exchange of the National Telephone Company has been held, in consequence of the notice given by the company to increase the rent from £5 to £8 per annum. After discussion, the meeting expressed itself in favour of the present rate, or as an alternative to dispense with the service. A general feeling was manifested in the direction of an improvement of the service, and complaints were made of want of attention at the central and of difficulty in telephoning with Sheffield and outside districts. It was decided to communicate the views of the meeting to the manager. It was announced that there were 126 subscribers to the Rotherham service, and that more than one-third of this number had given their opinion on the proposed charges.

Gas and Electricity at Newport.—The chairman (Mr. E. J. Phillips), of the Newport Gas Company, speaking at the half-yearly meeting on Monday, said that he did not think that the introduction of electric lighting would do any harm to the gas undertaking. The Corporation of Newport had decided to acquire an installation, at a cost of £30,000, but, under the circumstances, he thought the Corporation should have allowed a private company to see if they could make it pay, and not utilise the ratepayers' money on a speculation. The Alexandra Dock Company and the gas company were the largest ratepayers in the town, and they would not gain any advantage from the expenditure. It was proposed to confine the operations for the present to a small area, but all ratepayers outside that area would have to contribute.

Telephony in Glasgow.—The sub-committee on telephones of the Town Council have taken initial steps towards applying for a license for the municipalisation of the telephone. A section of the committee is in favour of a 10-mile radius, so as to include the outlying burghs and a number of other important towns within that area. The district manager of the National Telephone Company has issued a circular stating that the discomfort occasioned to some of the subscribers during the recent change in the system of operating the Glasgow switch-room of the company has been a matter of great regret to the directors. It was only after grave consideration, and at a very heavy expenditure of capital, that the call-wire system was adopted, and the directors believe that when subscribers and operators get accustomed to the system they will find it much superior to anything that has hitherto been in existence in this locality.

Cardiff.—The plan of Mr. Massey was presented on the 10th inst. at a meeting of the Cardiff Lighting Committee. Alderman Jacobs asked whether Mr. Massey could assure the committee that the distances which had been arranged between the public electric lamps were proportioned to give a good light and make the use of electric lighting a success. If the distances were such as those in the City of London it would be successful, but in St. Pancras it was a dismal failure. Mr. Massey said that the average distance between the lamps in St. Mary-street was about 50 yards, and that where the lamps were closest the distance between them was less than the distance between the lamps in Queen Victoria-street in the City of London, which the committee had found to be the best lighted street they had seen anywhere, and that in other streets the greatest distance between any two lamps did not exceed the maximum distance apart of the lamps at St. Pancras, London.

Chelsea v. London Company.—On Wednesday application was made *ex parte* to Mr. Justice Wright in the Chancery Division on behalf of the Chelsea Electric Supply Corporation for an injunction extending over a week restraining the London Electric Supply Corporation from laying any distributing mains for supplying the electric light within the area supplied by the plaintiffs, except in accordance with the terms of an agreement entered into between the two companies in July last. There had been correspondence between the parties, and the defendants having on Friday last justified what they were doing, this action was brought. Mr. Morton, Q.C., who made the application, on being called upon to explain the urgency of the matter, stated that the plaintiffs might be called upon to supply adjoining owners. Mr. Justice Wright granted an injunction over next Wednesday, but intimated that, in case the defendants felt that the order would do them any harm, they could apply to him on the morrow in Chambers to dissolve the injunction.

Bolton.—In connection with the municipal station to be erected in Spa-road, and which was referred to in our last issue, we may mention that Messrs. Hick, Hargreaves, and Co. have been successful in tendering for the boilers. The tenders for the supply of the engines have been considered, and that of Messrs. J. and E. Wood, Victoria Foundry, has been accepted. The engineer (Mr. Rider, M.I.E.E.) has submitted specifications for transformers and underground cables, which have been approved, and tenders for the supply were ordered to be obtained. The engineer has reported upon the tenders for the supply of dynamos and alternators with a tabulated list of such tenders, and the Lighting Committee has accepted that of the Brush Electric Engineering Company. The Gas and Electric Light Committee of the Town Council have recommended the acceptance of the tender of Messrs. John Fowler and Co. (Leeds), Limited, for providing an overhead travelling crane for the electric light engine house at a cost of £337, and that of Messrs. Bryan, Donkin, and Co. for fitting furnaces and boilers in connection with the new works at £285 on certain conditions.

Bradford.—The minutes of the Gas and Electricity Committee of the Town Council were presented at a quarterly meeting on Tuesday. Alderman F. Priestman (chairman of the committee), in moving the reception of the minutes, stated that the sales up to the end of June 30th, 1893, were £4,210, against £3,126, and the gross profit for the half-year was £2,293, against £1,673, whilst the net profit was £625. 16s., against £387. 7s. for the corresponding period. The total expenditure on the electricity works was £62,109, and there was a profit balance on the whole of the working of £915. 12s. 6d. He also included in the motion a recommendation that the necessary work required in the application of the "three-wire" system, at an estimated cost of £2,050, be proceeded with, and that the Council accept the tender of Messrs. Siemens for the supplying and fixing of two engines, with dynamos and two switchboards, for the sum of £3,025. It was absolutely necessary, he said, that they should adopt these extensions, as they had to refuse a very large number of applications. If they had double the amount of electricity to sell, customers would be forthcoming for it. Alderman Morley seconded the motion, which was carried unanimously.

Oil Insulated Mains.—We are informed by Messrs. Johnson and Phillips, of London and Charlton, that they are now able to undertake the laying of cables for the transmission of current at any voltage, and they guarantee the satisfactory working of the same on their oil insulated system and underground mains, which they work under the patents of the late Mr. D. Brooks and themselves. The firm have constructed at their cable wharf special machinery and oil tanks for the manufacture of this class of cable, and as all the work they have done up to the present time has given satisfaction, a very large business in the near future is anticipated. The firm state that this system can no longer be said to be in its experimental stage, as during the extremely bad weather last winter the whole of the distributing mains at Chatham, Rochester, and Strood were laid down on this system. The mains consist of two high-tension feeders running from the station to seven sub-stations placed at various parts of the towns. The energy having been transformed from 2,400 volts to 110 volts, is distributed down both sides of the street by means of low-tension mains also having oil insulation. Cast-iron house service boxes are fixed opposite every other house, and connections are made both to the transformer and houses by flexible lead-covered oil-insulated branch mains. There is also an arc light circuit running from one end of the town to the other. Each section before being finally connected up was severely tested with 5,000-volt alternating current, and although the circuit was frequently broken whilst the dynamo was run at this pressure, the mains did not afterwards show any weakness when tested with a sensitive reflecting galvanometer.

Lighting at Coventry.—On Tuesday, at the quarterly meeting of the Town Council, the report of the Electric Light Committee was presented. The committee recommended: (1) That the Corporation do themselves undertake the supply of electrical energy under the provisional order; (2) that the high-tension alternating transformer system be adopted for private lighting, and that street lighting be not at present undertaken; (3) that the site in Sandy-lane, which Sir Thomas White's trustees are willing to sell, be purchased from them at £350 an acre; (4) that a station be erected there of 150 kilowatt capacity, to supply 4,300 8-c.p. lamps, with mains and transformers suitable for 12,000 similar lamps; (5) that your committee be instructed to carry out the above recommendations, and to employ a consulting engineer to advise them upon the selected specifications and estimates; (6) that your committee be empowered to employ at the proper time an architect to prepare plans and specifications for the necessary buildings, and to obtain tenders for the same; (7) that your committee be instructed to frame and submit to the Council an estimate of the total capital outlay required, for the purpose of an application to the Local Government Board for the necessary borrowing powers. Your committee believe that the amount required will not exceed £15,000. Preceding these recommendations, the committee presented an account of their work, of which the following is a summary: On April 12, 1892, the Council adopted a report whereby the committee was authorised to accept the offer of an eminent firm of electrical engineers to submit, free of cost, a scheme and estimate for the establishment of a central electric light station, and any similar offers by firms of like standing; also to make enquiries in other towns. On August 16, 1892, the report of Mr. A. Bromley Holmes, the engineer consulted by the committee when obtaining the provisional order, was, at the request of the chairman of the committee, referred back to the committee with instructions "to take Mr. Holmes's letters into consideration, and recommend

to the Council a scheme of electric lighting." Mr. Holmes's report contained three main conclusions (1) That, having regard to local circumstances, the Corporation would do wisely to keep the electric lighting of the city in their own hands; (2) that no advantage was to be gained by delay; (3) that, bearing in mind that the committee looked rather more to private lighting than to the lighting of the streets, a low tension direct current system should be adopted, with a generating station at the old baths, or, if possible, near the centre of the city, and that £30,000 would cover the necessary expenditure. With the first of these conclusions the committee entirely agree. With respect to Mr. Holmes's second conclusion, the committee point out that by the terms of the provisional order the mains were to be laid in certain streets within two years of its date, and that in default the Board of Trade may revoke the order. The two years expired on June 11 last, but it is not probable that the Board will take the extreme course of revoking the order if they are satisfied that the Corporation will now proceed to exercise their powers under it with due expedition. No communication has yet been received from the Board on the subject. The committee are of opinion that, while the time devoted to enquiries has been usefully and profitably spent, the time has now come when operations for the lighting of the city should be taken in hand. Mr. Holmes's third conclusion must be considered in connection with the schemes submitted to the committee by various firms and the enquiries made. In submitting these schemes the various firms concerned had an entirely free hand; plans of the city and all other information which they required were furnished to them, and each firm was left to choose its own system and site. In the result three firms (Brush Electrical Engineering Company, Limited, Messrs. S. Z. de Ferranti, Limited, and Messrs. Hammond and Co., all of London) recommended the high tension alternating transformer system, with a station in Sandy lane, near the Cotton Mill; one (Electric Power Storage Company, Limited, London) recommended a high tension direct current system with motor transformers in sub stations and storage batteries, the generating stations to be placed in the Pool Meadow; and two (Electric Construction Corporation, Limited, of Wolverhampton, and Messrs. J. H. Holmes and Co., Newcastle) recommended a low tension direct-current system with or without storage batteries, the generating station being placed in the Pool Meadow. A comparison of the estimates which accompanied these schemes convinced the committee that, light for light, the high tension alternating transformer system involved the smallest capital outlay, and was, especially when the probability of an extension into the residential parts of the city was taken into consideration, the best adapted to the needs of Coventry. This conclusion, though at variance with the recommendation of Mr. Holmes, is in accordance with the opinion formed by the deputation who visited the Crystal Palace. In the meanwhile, Messrs. Siemens Bros. and Co., Limited, asked to be allowed to submit a scheme on the same footing as the other firms. As all the correspondence had been conducted privately, and no information had been allowed to go beyond the members of the committee, the committee considered that the request could be acceded to without injustice. Messrs. Siemens accordingly submitted two alternative schemes, one on the high-tension alternating transformer system, the other on a system combining high tension alternating generation with low tension continuous current distribution. The estimates accompanying these schemes confirmed the committee in their opinion of the greater cheapness of the former system. Alderman Singer (the mayor) moved, and Mr. Fowler seconded, the adoption of the report and recommendations. This was adopted.

PROVISIONAL PATENTS, 1893.

AUGUST 8.

15110. **Improvements in apparatus and devices for starting, stopping, and reversing electromotors.** Frank Alvord Perret, 70, Market-street, Manchester. (Complete specification).

15151. **Improvements in circuit-testing apparatus.** Frederick Sumner Palmer, 24, Southampton buildings, Chancery lane, London. (Complete specification.)

15156. **Improvements relating to telephones.** Parnell Rabbidge, 6, Bream's buildings, Chancery lane, London.

AUGUST 9.

15198. **Improvements in apparatus for obtaining ignition by means of electricity.** Leslie Bradley Miller and Maurice Walter Woods, 2, Gray's inn-road, London.

15217. **Improvements in electric cables.** George Cecil Dymond, 6, Lord street, Liverpool.

15231. **Improvements in electric arc lamps.** Alfred Julius Boult, 323, High Holborn, London. (A. Bureau, Belgium.)

AUGUST 10.

15248. **Improvements in joints for electric light, gas, water, and other similar fittings.** Ernest Alexander Claremont, 53, Arcade chambers, St. Mary's gate, Manchester.

15257. **Improvements in and connected with galvanic batteries.** Siegfried Marcus, 55, Chancery-lane, London. (Complete specification.)

15264. **Improvements in plating metallic surfaces and also prepared surfaces of non-conducting substances by electro-chemical deposition.** Pascal Marino, 24, Queen Victoria-street, London. (Complete specification.)

AUGUST 11.

15284. **An improved safety device for facilitating the replacing or removing of electric fuses.** D. F. Adamson, 76, Sinclair road, Kensington, London.

15322. **Improvements in instruments for telephonic and telegraphic transmission of speech or sounds.** Arthur Thomas Collier, Netria, St. Albans, Hertfordshire.

15337. **Improvements relating to electric arc lamps.** Eugene Daniel Tresel, 18, Buckingham street, Strand, London.

15338. **Improvements in cases for electric bell mechanism.** Louis Bourgeois, 18, Buckingham street, Strand, London.

15343. **Improvements in and relating to the attachment of electric lamps to their posts.** Wilhelm Oexnberg, 151, Strand, London. (Complete specification.)

AUGUST 12.

15355. **An improved electric battery.** Horace Seymour Pyne and Robert Thompson, 24, Highfield-crescent, Rockferry, Chester.

15366. **Improvements in electrical heating and cooking apparatus.** Gustavus Adolphus John Schott, George Adolphus Schott, and George Gustavus Schott, West End Mills, Longside lane, Bradford.

15373. **Electric light fixtures.** Frank W. Davenport, Providence, Rhode Island, United States of America. (Date applied for under Patents, etc., Act 1883, Sec. 103, 16th January, 1893, being date of application in United States. (Complete specification.)

15396. **Improvements in or connected with apparatus for the manufacture of chlorate of potash by electrolysis.** Ferdinand Hurter, 47, Lincoln's inn fields, London.

15406. **A new or improved "cut out" to be employed in connection with electric arc lamps.** William Hopkin Akester and the Akester Electric Syndicate, Limited, 57, Chancery lane, London.

SPECIFICATIONS PUBLISHED

1879.

4903*. **Telephones.** Scribner. (Clark and others.) (Amended specification.)

1890.

9125*. **Telephonic apparatus.** Kingsbury. (Western Electric Company.) (Amended specification.)

1892.

13375. **Electric meters, etc.** Spence.

14061. **Electric current machine and motor.** Aldred.

15066. **Electrical cut-outs.** Webber and Nisbett.

15840. **Electric arc lamps.** Crompton and Pochin.

16571. **Electric motors.** Woodhouse and Rawson United, Limited, and Rawson.

16644. **Measuring electrical currents.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

16805. **Electric search light apparatus.** Scott.

16877. **Telephone signalling apparatus.** Forbes.

16892. **Extracting, separating, etc., metals by electrolysis.** Tommasi.

16893. **Extracting, separating, etc., metals by electrolysis.** Tommasi.

1893.

6975. **Electric circuits.** Berry and Harrison.

8330. **Electric car brakes.** Company.

9302. **Contacts for electric railways.** Prewitt.

9821. **Galvanometers.** Lake. (Whitney Electrical Instrument Company.)

11578. **Electrically welding metals.** Thompson. (Coffin.)

11608. **Electrical heaters.** McElroy.

11609. **Electric switches.** McElroy.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.		2¼
City of London	—	11
— Pref.	—	12¾
Electric Construction	—	—
Gatti's	—	5¼
House-to-House	5	5¾
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	6
National Telephone	5	4¾
St. James', Pref.	—	8
Swan United	3¾	3¼
Westminster Electric	—	5½

NOTES.

Valence d'Agen.—It is proposed to light this town by electricity, water power to be used.

Tunnel-Lighting.—It is urged that the railway tunnels in and about Paris should be lighted electrically.

Dieppe.—An electric tramway is projected between Dieppe and Arques, with a possible extension to the Arques Forest.

The Corinth Canal.—This canal, which has just been opened to traffic, is lighted at night by means of 70 arc lamps.

Geneva.—It is proposed to hold at Geneva, in 1896, an international electrical exhibition in connection with the Swiss Country Exhibition.

Saint-Leonard.—The Municipal Council of Saint-Léonard (Haute-Vienne) has voted the money necessary for the electric lighting of the town.

Blackpool.—The flagstaff at the Royal Palace grounds has been split by lightning, and in the generating station in the grounds some of the meters were spoiled.

Exhibition.—Steps are being taken by various scientific gentlemen, seconded by financiers, for the holding of an international electrical exhibition in Paris next year.

Chemical Products.—The Société d'Electro-Chimie Soleure has been formed at Soleure, Switzerland, for the purpose of manufacturing chemical products by electricity. Works are to be erected at Luterbach.

Personal.—Mr. B. B. Skirrow, M.A. (Oxon), who has occupied the positions of demonstrator and assistant lecturer in the physics department of Mason College since 1888, has just been elected to the lectureship in physics and electrical engineering at the Manchester Municipal Technical School.

An Electrician Honoured.—As a public acknowledgment of the excellent work and research which Mons. Trouvé, the well-known French electrician, has accomplished in the field of applied electrical science, the "Melsens" prize has been awarded to him by the Société d'Encouragement pour l'Industrie Nationale.

An Electric Yacht.—An electric yacht plying off Southend Pier has been the means of extricating a party of volunteers from an unpleasant position. The volunteers went out on a sailing yacht which got becalmed a mile or two out. The electric yacht proceeded to the rescue, and brought back to shore the party of volunteers.

Manufacture of Steel.—The diamond making experiments conducted by M. Moissan have suggested to M. Jules Garnier a new method of producing steel. The steel is made by placing a bar of iron and a stick of charcoal together in a parallel direction in an electric firebrick furnace of a temperature of 1,000deg., and subjecting them to a strong current. It is claimed that the method is successful.

Leeds.—By neglecting to wear indiarubber gloves when attending to an arc lamp in the goods yard of the Midland Railway at Leeds, Mr. G. Sykes received a shock which resulted in death a few hours subsequently. This is another instance showing the necessity for providing a switch at the bottom of the lamp standard, so that the current, if passing, may be turned off before the lamp is trimmed or otherwise attended to.

An Electric Elevator.—A new type of elevator has been brought out in the United States for use at railway stations and theatres. It is always in operation, and consists of an endless inclined platform, moving at a uniform speed. Passengers step on the platform, and are conveyed from one landing to a higher level. The elevator is driven by an electric motor, and one of the single-file type can transport 3,000 passengers per hour.

Track-Laying under Difficulties.—The Consolidated Electric Railway Company and the local authorities at North Abington, Mass., have had a dispute as to the right of way of the former in a certain street. This resulted in a fight between the townspeople and the Italian navvies engaged in laying the lines of the company. The steamer of the fire brigade was brought on the scene, and a powerful stream of water was thrown on the Italians, thus dispersing them. This is track-laying under serious difficulties.

Blackpool.—It is suggested that the electric cars on the promenade should be overhauled at the close of the present season. The traffic upon the tramway during the past two or three weeks has been very large, and some breakdowns and accidents have occurred. The cars have borne the great strain well, but there have been many evidences that the line itself will need attention when the quiet period comes. It is urged that immediately the season is over the tramway system ought to be put in complete repair, even if the new method of electrical propulsion is not ready for adoption.

Hydraulic Power.—An important scheme for the utilisation of water power is due to M. Ritter, who proposes to tap the River Sarine, near Courtepin, Switzerland. A dam is to be erected, and a portion of the water allowed to pass through a tunnel, and then along a canal to the Milafin fields, where a reservoir is to be constructed. The water would, it is said, yield 10,000 h.p., which would be distributed from Moudon and Estavayer to Morat and Aarberg. It is believed that the utilisation of power would lead to the establishment of many manufacturing works. A provisional committee has already been formed to deal with the matter.

Electric Quackery.—No word is so flagrantly misused as the word "electricity." In country districts, remarks the *Globe*, one has but to mention "electricity" to see a thrill of awe run through one's listeners, and sharp impostors have not been slow to take advantage of this attitude of wondering homage. Every quack who has any rubbish to sell now labels it "electric," and charges heavily for the mystery of the thing, with disastrous results to the villagers. A correspondent of a contemporary tells of a poor woman who presented herself at a hospital with a worthless pair of "electric" spectacles, for which a "gentleman" had made her pay a guinea!

Injunction.—On Wednesday an application was made to Mr. Justice Wright, in the Vacation Court, on behalf of the Chelsea Electricity Supply Company, asking for an injunction restraining the London Electric Supply Corporation from laying or distributing mains for the supply of electric light within a certain radius. The defendants opposed the injunction, one of their grounds being that they were under an agreement to supply the Court Theatre by the 1st September. His Lordship held that the defendants could not lay mains within the stated radius, except if required by the Board of Trade; and as they were not so requested, he granted the injunction asked for until the trial of the action between the companies.

Dunedin.—It seems that there is not at present much probability of the proposed electric tramway at Dunedin being constructed. The Government officer, Dr. Lemon, is of opinion that the double-trolley system is more desirable than the single trolley method. The negotiations in con-

nection with the undertaking have been on the basis of the adoption of the single-trolley system, and Dr. Lemon's view of the matter may prevent the project being carried out. The promoters of the tramway would do well to draw the attention of Dr. Lemon to the experience gained with the double-trolley system at Cincinnati, Ohio, and he will then probably change his opinion as to the advisability of causing the double system to be adopted.

"The Electrical Review." — Our contemporary is ofttimes amusing because it cannot help it. In its last issue there is an attempted witticism about 'bus-lighting; but its meaning is as hard to extract as that of one of Mr. Gladstone's orations. The probability is that a certain amount of space had to be filled, and with the weather so atrociously hot nothing more could be done than to make a guttural chuckle over atrocious puns. Wake up, you dear Old Dutch! you are getting frivolous in your old days. Time was when hitting straight from the shoulder was not uncommon; and, oh! the pity of it, if this gives place to aimless punning. Do you really wish to take up the cudgels on behalf of the paper criticised? If so, go ahead; we are game.

Telegraphy between Kashgar and China.—It is announced that direct communication by telegraph between Kashgar and the interior of China will be established during the present autumn. With the completion of this important line the whole continent of Asia will be traversed by the telegraph, excepting only the region lying between Kashgar and Oscha. When the Russian line connecting these termini is completed—and no objection to the junction has been raised by the Chinese Government—all telegrams from the Far East to Europe are expected to come by this route. Official despatches from the Far East to the British Foreign Office will probably continue to be sent by the present route as well as British mercantile telegrams.

Pocket Telephone. —The Newcastle policemen are reported to have been provided with pocket telephones. As described by one of the local papers, "the apparatus consists of a combined mouthpiece and earpiece, with about a foot or more of wire attached, an affixing pin, and a small key. This apparatus is to be used by the officers in connection with the fire alarms placed at various parts of the city. Instead of breaking the pane of glass in case of a fire occurring in the neighbourhood—as an ordinary individual would have to do—the policeman opens the door with his key, places the affixing pin in a socket provided for it in the lamp, and is in direct communication with the fire brigade." We wonder where the transmitter and battery are situated.

A New Accumulator.—A new type of secondary battery has been devised by M. Hard. A silver wire is kept in a central position by means of a triangular arrangement above and below discs impregnated by the active liquid. To avoid the difficulties inherent to this class of accumulator owing to the pressure of the gas, the upper part of the battery is closed by a hard indiarubber cover in the form of a funnel having a central hole provided with a valve. This valve opens and closes automatically, following the intensity of the pressure of the gas generated. The funnel-shaped cover prevents the escape of the electrolyte in case the battery is overturned. The action of the accumulator is said to be tolerably constant, and it can be used for various purposes.

Measuring the Insulation of Conductors.—An apparatus has been devised by MM. Ducretet and Lejeune for the purposes of measuring insulation resistances in general. It is not submitted as new, but it is considered interesting on account of its practical and portable form, and the large extent of measurements which it permits of being made with precision. The method is as follows: A current is passed from a battery through a fixed resistance (10,000 ohms), which serves as a comparative resistance and through a galvanometer, and the deviation obtained is noted. The current from the same source is then passed through the resistance to be determined and through the galvanometer; this deflection is noted. By calculating that the direct ratio of the intensities is equal to the inverse ratio of the resistances, the result is an equation from which the resistance sought for can be immediately deduced.

Indicating the Position of Trains.—An apparatus for enabling signalmen to ascertain the position of a train on the line has been devised by Prof. Pellat, of the Paris Sorbonne, and is intended to prevent collisions between trains. It consists essentially in the arrangement in the signal-box of a band of travelling paper impregnated with iodide of potassium. A platinum stylus moves over the paper, and when a current of electricity passes through the stylus and paper the iodide is decomposed, leaving a blue mark on the paper, as in the chemical telegraph of Bain. This current is sent by the moving train in the following manner: The wheels press down pedals placed at intervals along the rails, and complete the circuit of a battery connected with the platinum stylus and paper of the apparatus situated in the signal cabin. The marks thus made on the paper indicate the position of the train, and enable the signalman to trace its course along the line.

Traction at Croydon. —Some time ago, as will doubtless be remembered, the Jarman system of accumulator traction was experimentally tried on the Croydon tramways, there being generally two cars in service. The working of the cars was suspended at the termination of six months' operation, and, as Mr. W. J. Carruthers-Wain remarked at a meeting of the Croydon Tramways Company on Tuesday, the Electric Traction Syndicate had not yet been able to renew its running on the line, or to make any definite arrangement in relation to that matter. This particular form of traction was a novelty and extremely beneficial to the traffic. On the other hand, two new motors, which are to be run at the expense of the owners, have been placed on the line for experimental working. One is the Conolly compressed-gas motor, and the other the Lubrig gas motor. The Conolly motor has already been tried on the lines of the Deptford Tramway Company.

Repairing Incandescent Lamps.—A fairly large industry has arisen in the United States in the repairing of Edison incandescent lamps, and it is calculated that no less than 10,000 lamps are repaired daily in that country. Lamps having broken filaments are perforated by crushing the end of the projecting tip of the lamp, and then revolving it rapidly in a lathe whilst the end of the lamp is heated by a gas blast-flame until the glass becomes softened. The centrifugal force, aided by a former placed in the hole, increases the diameter of the latter from one-twentieth of an inch to about three-fourths of an inch. After the remains of the old carbon have been cut away, the interior of the lamp is cleaned by special tools. A new carbon filament is fitted by electroplating of copper at its terminals to minute copper tubes about $\frac{1}{16}$in. diameter and $\frac{3}{8}$in. long. These tubes are inserted in the lamp and secured to the projecting copper and platinum which held the original filament. The next operation is to soften the end of the lamp, and to reduce the orifice to $\frac{1}{4}$in. and seal it to a tube. The lamp is then exhausted and finished in the ordinary way.

Hotel-Lighting.—The last number of a contemporary devoted to the hotel interests contains a long detailed and

illustrated description of the fine mansion at Langlands Bay, near Swansea, which was originally built as a private house by Mr. Crawshay, the well-known South Wales millionaire, but which has been altered and enlarged into a magnificent "caravanserai," principally, of course, for tourists and the usual floating population of a seaside resort. There appears, from the published description, to be a very complete electric equipment of bells and signals in the house, but no mention whatever is made of the presence or lack of electric light throughout the building. Yet one would think that in a summer hotel, of all places, such a method of illumination would be employed, not only to attract a greater number of visitors, but also to secure the best classes. There is room for very considerable development in improved lighting of country and seaside hotels, and it need not be thought in any way essential that a hotel, to be successfully and economically lighted by means of electricity, must be situated in a large town or city.

Humours of the Post Office.—A correspondent addressed to the *Times* a week ago a letter complaining of the humours of the postal telegraph service. He wanted to send a telegram from London on Sunday to the North of England, but he was told that the office was closed. Desiring to have his message forwarded to the nearest office for further transmission, he asked what was the nearest office open. No one could tell him, and there was no map for him to inspect. The official told him that he might see one at Charing Cross, but no. He had to go to St. Martin's, and even there his wishes were not met, and so forth. Then there was the question of the money deposit to cover all possible porterage. This is sad indeed. Of course other correspondents have come forward with similar and other tales as to the eccentricities of the Post Office; but what do they want? The world got along before the telegraphs and before the introduction of railways and steamships, and it can get along without the trouble of Sunday telegraphy. Some people are never satisfied; they want the millennium at once.

The Telephone on Railroads.—The Pennsylvania Railroad Company has adopted long-distance telephones for communication between the leading executive offices of the company. They will, it is calculated, save much valuable time and will aid in the more rapid transaction of urgent business. The important points on the Pennsylvania system thus connected with Philadelphia are New York, Jersey City, Wilmington, Baltimore, Washington, Harrisburg, Altoona, Chicago, and St. Louis. The wires in these and other cities will run into the private offices of the higher officials, for whose exclusive use in the transaction of the company's business the system is intended. No one will be allowed to use the telephones except these officers, even though communication with an official is desired. The telegraph, with all its advantages over former methods, did not ensure absolute confidence between officials, because the message passed through the hands of two and sometimes three or four operators. Consequently, under such conditions, important questions could only be settled after a personal meeting between the officials, and this necessitated a large amount of travelling. Much valuable time will now be saved and business transacted in quicker time.

Water Power.—The utilisation of water power has been undertaken at Tampa (Fla.) by the erection of a dam across the Hillsborough River, six miles from Tampa. This dam gives a 14ft. head of water, which is used to operate six Leffel turbines, varying from 175 h.p. to 250 h.p. each, and which can develop about 1,100 h.p. Only two or three of the turbines are at present being used. One drives a Thomson-Houston generator which is supplying a 2,000-volt lighting circuit, on which Thomson-Houston transformers from 2,000 to 50 volts are used. A second is used on a Thomson-Houston generator which supplies a 500-volt street railway and power circuit. The company doing the work is known as the Consumers' Electric Light and Street Railway Company. They have about five miles of line laid in the city, and are operating four tramcars and one double-decked car. They have four trailers, which can be attached to the motor cars when desired. The current runs from the power-house to Tampa, a distance of six miles, bare copper wires being used to convey the current this distance. The track is being extended to Port Tampa City, nine miles south west; then it is to run six miles north-east to the power-house, making a 15-mile aerial line.

Sparking at Commutators.—The study of the avoidance of sparking at commutators seems to be very much to the fore in technical papers at the present moment, and rightly enough so, if we can get to any good results. Following Mr. Sayer's contribution to the subject, M. Rechniewski has written some practical papers which we are giving in our other columns. In *L'Electricien* last week still another writer, M. J. Staner, takes up the pen to clear the matter in an article on "The Lead of Brushes in Continuous-Current Dynamos." On open circuit, says the author, the brushes will be on the neutral line. At what position should they be set when the current is flowing? He answers this question in detail, and works out his conclusion mathematically. We will content ourselves by giving the result to which he arrives: "In conclusion, we can suppose in practice the brushes to be on the neutral line, and admit, as demonstrated, that the angle of lead is practically proportional to the square root of the armature current." This rule may be useful to the attendants of large dynamos, though we suppose, as before, they will in ordinary cases set the brushes by trial on the position of least sparking. The researches of Rechniewski on means of extending the allowable change of load for the normal position of brushes without sparking, by considering the interior construction of the dynamo, would seem to appeal far more strongly than the mere production of a formula to the instincts of electrical engineers.

Submarine Mines.—By the invitation of Major Knight and other officers of the Mersey Volunteer Submarine Miners, a large party of ladies and gentlemen embarked last week on the War Office steamer "Lord Heathfield," and were taken down the River Mersey to a point about half a mile beyond Perch Rock Battery. The first experiment was very striking. A circuit-closing apparatus, which outwardly resembles an ordinary mooring buoy, was fixed at a certain point in the water, so arranged that the bow of the "Lord Heathfield" should "bump" against this, and cause the first explosion. Immediately the steamer touched the circuit closer, a current was sent along a submarine wire to a special room at the Perch Rock Battery, setting in action a relay, from which the current passed to an exploder attached to a charge of 100lb. of gun-cotton, enclosed in an indiarubber bag, with a wooden frame, and suspended several feet beneath a barrel floating on the water, about 200 yards from the "Lord Heathfield," and half a mile from the battery. The explosion took place instantaneously, the barrel was blown into a thousand fragments and the water rose to a great height. Four or five other charges were similarly exploded in the usual fashion by means of a key. The mechanism inside the circuit-closing apparatus has not yet been disclosed. Of course, the buoys would contain explosives in time of war; and Liverpool may, in such an untoward event, feel tolerably secure from invaders by sea.

Penn'orths of Electric Light.—Electricity, it is admitted, has been driving out of use to a large and increasing extent the use of gas in our clubs, mansions, warehouses, and other large buildings, and the faces of a good many shareholders in gas companies have lengthened in consequence. Mr. George Livesey, the chairman of the South Metropolitan Gas Company, comes to the rescue, however, and, like the Midland Railway, caters for the lower classes when the highest becomes unprofitable. Not contented with supplying the majority of shops and middle-class houses, he now aims at affording a chance to the workers of burning gas in their cottages instead of oil. This is done by means of a "penny-in-the-slot" arrangement, the meter being so arranged that a quantity of about 26 or 27 cubic feet is allowed to pass on the insertion of a penny in the usual slot. This, of course, is sufficient for about six hours' lighting of a single jet, and therefore the cost for an evening's light need be no more than 1d. The fittings, of course, are supplied—working-men cannot afford to purchase these; but otherwise great readiness has been shown in the adoption of gas instead of oil. That there is room for the venture seems proved by the fact that not much more than one-third of the total number of householders in the South Metropolitan Company's district is supplied with gas, and this is not due to the competition of electric lighting, as no supply of the latter is available to any great extent. If "penny-in-the-slot" gas is found to be a boon, why, it may be asked, may we not have pennyworths of electricity? From a technical point of view, there is no objection whatever, but the trouble is in supplying the fixtures and making the necessary connections. As soon as the owners of property can be brought to see the advantages of wiring or connecting houses in readiness for a supply, then, of course, the chief stumbling-block will be removed; but this is looking a long way ahead. At 6d. a unit, a "penn'orth of electricity" ought to be enough to keep a 10-c.p. lamp alight for five hours.

Hearing and Seeing.—Paragraphs have been going the round of the press to the effect that the principle of hearing and seeing by electricity is the same, and this under the authority of Prof. Bell, who is stated to say that all we require to see by electricity is a diaphragm as sensitive to light vibrations as the one now used is to sound vibrations. Prof. Bell is stated to have further said: "Morse taught the world years ago to write at a distance by electricity. The telephone enables us to talk at a distance by electricity, and now scientists are agreed that there is no theoretical reason why the well-known principles of light should not be applied in the same way that the principles of sound have been applied in the telephone, and thus allow us to see at a distance by electricity. It is some 10 years since the scientific papers of the world were greatly exercised over a report that I had filed at the Smithsonian Institution a sealed packet supposed to contain a method of doing this very thing—that is, transmit the vision of persons and things from one point of the earth to another. As a matter of fact, there was no truth in the report, but it resulted in stirring up a dozen scientific men of eminence to come out with statements that they, too, had discovered various methods of seeing by electricity. That shows, what I know to be the case, that men are working at this great problem in many laboratories, and I firmly believe it will be solved one day." This is all very pretty, and, so far as vibrations are concerned, has been said before, but in these general statements too little explanation is given, and that misleading. Sound vibrations are wholly due to the vibrations of ponderable matter, light vibrations are the vibrations of imponderable matter—or what we have always been told is imponderable—the hypothetical ether. These latter vibrations do affect ponderable matter, as is proved by our own eyes. Again, electrical phenomena are supposed to be due also to some action upon the ether. In telephony the sound waves first act upon the diaphragm and cause it to vibrate. These vibrations influence the etheric electrical action; this action is propagated to a distance, and in its turn influences a second diaphragm. Suppose we could get a diaphragm sensitive to light vibrations, would that enable us to see by electricity in like manner as we hear at a distance by the aid of electricity? Most emphatically, no; and most emphatically, the principle involved is not the same, Prof. Bell notwithstanding. We do not see by means of direct, but by means of reflected light, which makes all the difference to electric "seeing."

A Large Search-Light.—What is classed as the largest and most powerful search light in the world has just been completed by the United States General Electric Company, and is now being erected at the Chicago Exhibition. It stands about 10ft. 6in. high to the upper side of the ventilator on the top of the drum, and the total weight is about $2\frac{3}{4}$ tons, but so perfectly is it mounted and balanced that a child can move it in any direction. The reflecting lens mirror used in this projector is 60in. in diameter. It is a concave spherical mirror of the Mangin type, free from spherical aberration, reflecting a sensibly parallel beam of light. It was manufactured especially for this projector in Paris, France, and is a most perfect specimen of optical work, $3\frac{1}{4}$in. thick at the edges and $\frac{1}{16}$in. thick at the centre, and weighs about 7cwt. The metal ring in which it is mounted weighs about 7cwt., and the total lens, ring, and cover weigh about 15cwt. This great mirror is mounted at one end of the big drum, the outer end of which is furnished with a door consisting of a metal rim in which are fixed a number of plate-glass strips $\frac{5}{16}$in. thick by 6in. wide. Inside this drum, and sliding upon ways arranged on the bottom, is placed the electric lamp, the source of the light which is reflected by the mirror. It is entirely automatic in its action, is 6ft. high, and weighs about 400lb. The carbons used are also made especially for it. The upper or positive carbon is $1\frac{1}{4}$in. in diameter and $22\frac{1}{2}$in. long, with a $\frac{5}{16}$in. core of soft carbon running from end to end through its centre. The lower or negative carbon is $1\frac{1}{4}$in. in diameter, is 15in. long, and also has a core of soft carbon running through its centre. In addition, its outer surface is heavily coated with copper. The positive carbon is set a little in front of the negative, and thus almost all the intense light of the incandescent crater is cast upon the reflector. The maximum current at which this lamp operates is 200 amperes, and at this current the lamp has a luminous intensity of about 90,000 to 100,000 candles, and the reflected beam is said to have a total luminous intensity of about 375,000,000 candles. Ventilators at the top and sides allow a constant current of air to pass through the drum and dissipate the heat generated by the arc lamp; and they are so arranged that no light can escape through them. All the connections for adjusting the positions of the carbons and the lamp are brought through the drum to the outside, and are arranged in close proximity to one another at one side, so that all may be manipulated by the operator without moving from his position. Through openings in the drum covered by densely-coloured glass the operation of the lamp may be watched and its adjustments verified. The drum is supported by trunnions in bearings at the top of a Y-shaped fork, set in a base-plate, and the whole is supported on a system of friction wheels, forming a turntable resting upon

the top of a massive pedestal supporting the whole structure. The drum, fork, and base-plate may be rotated horizontally on the turntable either by hand or by gearing provided for this purpose. The drum may also be raised or lowered in a vertical plane.

The Edison Lamp Patent.—It seems that a decision of the United States Supreme Court alone will definitely fix the date of expiration of the Edison lamp patent. The *Electrical World* of New York has collected various facts bearing on the matter, and in commenting on it says: "Of the three main legal points not yet settled by a final decision of that court, two are given little weight. A third one, however, in regard to whether the date of application or the date of issue of an American patent shall prevail in determining priority of date with reference to foreign patents, rests upon a more debatable basis, notwithstanding the unanimity of the lower United States courts in deciding in favour of the date of issue. The first point of law is as to whether the life of an American patent issued subsequent to a foreign patent will be limited by the life of the foreign patent if the patentee is an American citizen. This has been decided in the lower United States courts in the affirmative, and no weight seems to be attached to the negative contention. The second point of law is in regard to which of the three dates on the English patent, which expires November 10, 1893, shall prevail. There have been several decisions on this question, and all have been in favour of one or the other of two dates. Both of these, in the case of the Edison patent, are subsequent to the American date of issue, and therefore do not affect the American life of the patent. Owing, however, to the Edison patent attorneys in an endorsement on the American patent wrongly designating November 10, 1879, as the date of the English patent, which is previous to the date of the American patent January 27, 1880), it may be contended in court that the date thus given should hold and consequently the American patent expire with the English one on November 10, 1893. It is not thought, however, that there is any hope of maintaining this point, particularly as a court has declared the endorsement in question void, the Commissioner of Patents having exceeded his authority in admitting it. The third point, to which we referred first, has strong equities in favour of the date of application, besides one or more points of law. Those who hold this view contend that it is unjust that the American patentee should have his home patent limited in life by a foreign patent because a foreign patent office has been more expeditious than the American one. The applicant has absolutely no control over the date of issue in any case, and should the English patent issue prior to the American one, the life of the latter is only 14 years, instead of 17 when the American patent is first issued. As in all foreign patent offices the time is almost always less between the date of application and the date of issue, the effect of the law, as interpreted by the lower courts, is to deny a patentee a life of 17 years to his domestic patent if he should also take out foreign patents—a state of affairs surely never contemplated by the framers of the statute thus construed. Notwithstanding that all of the decisions of the lower United States courts have been against accepting the date of application, it is held by many that if the same courts were not bound by their previous decisions they would decide differently at the present time; this, it is asserted, has been indicated by expressions from the bench and by the fact that the United States Supreme Court has reversed the lower courts in other questions of law under the same statute. While it is thus not at all certain that the Edison patent will expire with the Canadian patent on November 19, 1894, yet the chances that the United States Supreme Court will overrule the point of law repeatedly and unanimously affirmed by the lower courts has the odds largely against it."

Lighthouse Illuminants.—In view of the facts adduced by authors in papers read before the recent meeting of the International Maritime Congress in the metropolis, and which have been reproduced in these columns, the following statements will doubtless cause considerable surprise among many maritime people. The remarks have been published in a provincial daily paper, and from which we quote as follows: "Captain J. T. Bragg, R.N.R., adviser to the Liverpool Steamship Owners' Association, which represents the Cunard, White Star, and other lines, says: 'In my opinion, based upon nearly 14 years' experience in the Transatlantic passenger trade, the adoption of such a light as the "Giant Lens Lighthouse Gas-light," and a powerful fog syren on the Old Head of Kinsale, would materially increase the safety of the navigation to the mail steamers and other vessels which have to make Queenstown a port of call. An electric light of the same power and brilliancy would not show so far in hazy weather, as from its colour being more nearly assimilated with that of the fog it is more readily blurred out, whilst the gas flame, being of a different colour to the fog, would more readily be seen at the same distance. In confirmation of the above, when I was in command of the ss. "Anterior," bound round from London to Liverpool, at night, at a short distance east of Lizard Point a fog came on; as we approached the point we heard the sound of the Lizard fog syren. The two lights on the Lizard are powerful electric lights, which we were anxiously on the look-out for, but we were unable to see them, as they were completely obscured by the fog, whilst we were well within the sound of the fog syren, and only passing at a safe distance outside the dangers lying off the point.' Captain N. N. Digman, of the ss. 'Tempo,' says: 'The electric light is a bad light to see in hazy or foggy weather; far worse than an oil or gas light.' Captain T. Thomson, R.M.S. 'Munster,' remarks: 'I am sure the new light will pierce fog far better than the electric light. I have seen a great deal of the latter light at Holyhead, and consider it a very poor light for foggy weather.' Captain Wm. Dane, ss. 'Sinloo,' Newcastle, says: 'I have many times passed the new electric light at St. Catherine's Point. It is no doubt a very bright light, but in my opinion it is much too bright and dazzling, which makes it difficult to find out a ship's true position. In fog it is soon obscured.' Captain Boyd, of the ss. 'Countess of Dublin,' observes: 'I have often passed quite close to the electric lights on the south coast of England in hazy weather and found them invisible. In fact, to my mind, as a lighthouse light the electric light is quite useless.' Captain J. Henderson, secretary British Shipmasters' and Officers' Society, puts his views in these terms: 'I am of the same opinion as I have ever been—that the electric light for lighthouse purposes is a delusion and a fraud on the sailor. I nearly lost my life on Dungeness Point when the electric light was put there. The Trinity House yacht, "Captain Wallace," got on shore there—so much for electricity.'" These statements differ from the results obtained by Mr. Stevenson mentioned in our last issue, and also from the experience gained in the electric lighting of lighthouses in France as referred to by M. Blondel and M. Bourdelles. In fact, it has been shown that in all weathers and at all distances the penetration of the electric light has proved to be superior to either gas or oil lights; and in face of this it is difficult to understand the statements quoted above.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC.MEM.INST. ELECTRICAL ENGINEERS.

INCANDESCENT LIGHTING.

(Continued from page 127.)

Analysing this table, it may be remarked that lamps of type A take extremely small initial power—only 1·5 watts per candle-power, but their life is soon ended—only lasting 45 hours. Independent of the terrible heavy cost of lamp renewals, the trouble and labour involved in the renewals would prohibit their use. Consider the work to be done in a building having, say, 1,000 lamps. A fresh lamp would have to be put in somewhere every three minutes. The mean watts per candle-power is certainly lower than what is required for a lamp of type E, and there is hence a saving of cost of power; but an E lamp has 1,000 hours' life, and 22 lamps of the A type would have to be bought in order to get the same hours of burning as one lamp of the E type. Lamps used at this rate will soon bring up the expenses and swamp the saving that is effected by the small consumption of energy. Furthermore, type E after burning 1,000 hours will still give a good light of 12·5 c.p., while absorbing the same energy as at the start—namely, 54 watts; but a lamp of type A after burning 45 hours only gives 5·6 c.p.—a light so poor that if the lamp were not at the end of its life it would not be worth while using it. An E lamp at the end of its life of 1,000 hours consumes only 23 per cent. more power per candle-power than at the commencement of its life, whereas an A lamp at the end of its life of 45 hours consumes 143 per cent. more power per candle-power than at its commencement, the increase being more than six times as much. These figures show how extremely rapidly the A lamps deteriorate, and that it is only in the early stage of their life that they can claim to be efficient and economical in the true sense.

Having discussed the question of efficiency of lamps, so far as the maker is concerned, we must now go further, and find out the efficiency of the lamp from the consumers' point of view, otherwise that of £. s. d. The actual running cost of an incandescent lamp may be composed of two factors, as follows: (1) The cost of lamp renewals; (2) the cost of energy consumed.

The first factor depends on the life of the lamp, and the shorter this is the more will the cost be for lamp renewals. The second factor depends on the maker's efficiency, or the mean watts consumed per candle-power, and also on the price of electricity. The cost of lamps of, say, 16 c.p. may be taken as fixed, and in view of the expiration of lamp patents in November, we may put down the cost of a lamp at 2s., this price being the same for all lamps of 16 c.p., whatever their efficiency and whatever their life may be.

The price of electric energy will vary according—some places it is only 5d. per unit, at others as much as 1s. per unit is charged. When electricity is generated in private establishments, such as in factories, the cost of production is very low, and may be put down at, say, 2d. per unit, so the running cost will be calculated over a range of from 2d. to 1s. per unit. From this it is easy to see that the price of electricity has a good deal to do in deciding how to run the lamp, because when the cost of supply is high, it may be best to slightly overrun the lamp. On the other hand, when the cost of supply is low, they can be run slightly under the normal pressure. This latter case particularly applies to private supply, such as a large factory, where the cost of generating electricity is extremely low.

Tabulation 27 shows the total running cost per candle-power hour of the five types of lamps given in Tabulation 26, calculated out for prices from 2d. to 1s. per unit, and based on Siemens and Halske's data in Tabulation 26.

In the case of type A, which takes an initial consumption of 1·5 watts per candle-power, the cost of lamp renewals is nearly twice as much as the cost of electric energy, even when at 1s. per unit, the exact figures being:

lamp renewals = ·0626, energy = ·0342; total = ·0968.

TABULATION 27.

Price of supply unit in pence.	Total cost of 1 c.p. per hour in pence.				
	A.	B.	C.	D.	E.
2	·0683	·0207	[illegible]	·0100	·0093
3	·0711	·0244	·0180	·0141	·0132
4	·0740	·0281	·0222	·0181	·0170
5	·0768	·0318	·0264	·0222	·0209
6	·0797	·0355	·0307	·0262	·0247
7	·0825	·0392	·0352	·0302	·0286
8	·0854	·0429	·0391	·0342	·0324
9	·0882	·0466	·0433	·0383	·0363
10	·0911	·0503	·0475	·0424	·0401
11	·0939	·0539	·0517	·0464	·0440
12	·0968	·0576	·0559	·0504	·0478

With type B, taking 2·0 watts initially, the two components nearly balance when the price is 4d.; then

lamp renewals = ·0134, energy = ·0147; total = ·0281.

With type C, taking 2·5 watts initially, we have at the lowest price, 2d.,

lamp renewals = ·00544, energy = ·00842; total = ·0138.

With type D, taking 3·0 watts initially, we have at same price,

lamp renewals = ·00201, energy = ·00808; total = ·01.

With type E, taking 3·5 watts initially and at same same price of 2d.,

lamp renewals = ·00166, energy = ·0077; total = ·00936.

In all the above cases the lamp renewals remain constant throughout the range of prices per unit, and even when 1s. per unit is charged, type E costs less than one-half of type A.

When a lamp reaches the end of its life its filament breaks, and so the light ceases, because the circuit is broken. Upon examining these spent lamps, it will be observed that the filament nearly always breaks from about ¼in. to ½in. below one of the platinum joints, occasionally they will break just before the bend; the slightest fracture of the glass bulb of the lamp will lead to the destruction of the filament on account of air getting inside. One brake horse-power will run about 10 lamps of 16 c.p., and one kilowatt of electric energy will run 15 lamps at least, possibly 16.

Incandescent lamps are run in parallel at a constant pressure, the current increasing or decreasing according as the lamps in use increase or decrease. For example, if there be 50 lamps of 16 c.p. in use, worked at a pressure of 100 volts, they would probably take a current of about ·6 ampere each, or a total of 30 amperes, and this gives a consumption of 3,000 watts of electrical energy. Increase the number of lamps to 100: the current taken will now be 60 amperes, and the electrical energy 6,000 watts, the lamps being in parallel. When the number is doubled there are double the number of paths for the current to traverse, consequently the total resistance of the circuit is halved, and since the pressure remains constant, therefore, by Ohm's law, the current becomes doubled. The greater the number of lamps the greater the current, and hence the greater the section of the mains.

The resistance of carbon decreases as the temperature rises, which is the exact opposite action of metals. This decrease is only very little for every degree C. increase of temperature, and the resistance of the filament of an incandescent lamp when alight is five-sixths the resistance when cold, so that in calculating the electrical energy consumed by a lamp, its resistance when hot must be taken. The resistance of a lamp of 16 c.p. when alight, and worked at a pressure of 100 volts, is about 160 ohms, and when cold, or not alight, it is about 190 ohms. The following data concerning the filaments of various lamps may prove interesting, all being worked at 105 volts pressure. The diameter is a little less than what it would be when the lamp was new, owing to its disintegration:

100 c.p. .... length, 28·6 cm., diameter, ·0635 cm.
50 c.p. .... length, 26·0 cm., diameter, ·037 cm.
16 c.p. .... length, 23·0 cm., diameter, ·013 cm.

When electric power is distributed over wide areas from

one central source it is impossible to have the same potential difference everywhere, so that lamps that are situated near the source must inevitably be run at a greater pressure than those at the farther points. The Board of Trade allow a variation of 4 per cent of the working pressure, so that there is a margin of 8 per cent. altogether, since the variation may be 4 per cent. below normal pressure or 4 per cent above normal pressure. If the normal pressure is produced at a point or zone midway between the source of generation and the farthest point supplied, then a 16 c.p. lamp placed near the source will give about 20 c.p., and when placed at the farthest point, only about 12 c.p.; this is when full advantage is taken of having the pressure at the source 4 per cent. too high, and at the farthest point 4 per cent. too low. Evidently the increase of candle-power is accompanied with a short life, and the decrease of candle-power with a long life. This maximum variation of pressure occurs when the maximum number of lamps are burning—that is, when the current in the distributing mains is at its greatest; and as the current decreases and the number of lamps alight decreases, so the variation of pressure will decrease and approach nearer the normal pressure.

(To be continued.)

MEANS OF DIMINISHING SPARKING IN CONTINUOUS-CURRENT DYNAMOS.*

BY W. C. RECHNIEWSKI.

(Continued from page 159.)

Influence of the Winding.—The choice of a winding is not unimportant from the point of view of the sparking, and it is this latter consideration which ought to be most regarded; for from the point of view of production of energy all windings are much alike.

Let us consider first of all the two-pole dynamos. For these we have the choice between drum winding and ring winding.

I have already proposed to consider the propensity to sparking as proportional to the change of the flux traversing the short-circuited coils, when the current varies by a determined fraction of the current, c_n, of the section—for instance, when the current is reversed and taken from c_n to $-c_n$. Let us compare the two windings.

Let F be the normal magnetic flux of the dynamo, N the number of sections on the armature, n the number of turns per section with drum winding.

In small machines in general the mechanical considerations limit the number of segments of the commutator, and consequently the sections in the armature. We will suppose the same number of sections for the two windings. Let C be the current at the moment considered. Then, in these conditions, it will be noticed first that one turn encloses the complete flux, F, in the case of the drum winding, and the flux $\frac{F}{2}$ in the case of the ring armature, and that the number of turns per section is twice as large for the ring as for the drum winding.

When the current changes suddenly its direction in the section under the brushes, that is, passes from $\frac{C}{2}$ to $-\frac{C}{2}$, the changes of flux traversing the circuit is, for drum winding:

$$\alpha \,.\, F \,.\, C \,.\, n^2,$$

where α is a factor dependent on the form of the characteristic at the point considered. Exactly, α is equal to the length of the sub-tangent expressed in ampere-turns, and taken on the characteristic at the point where the machine is working normally. It is easy to take off this value on the characteristic given for any machine.

For ring winding we shall have for the same expression—

$$\alpha \,.\, \frac{F}{2} \,.\, C \,.\, (2\,n)^2 = 2\,\alpha\,F\,C\,n^2,$$

the number of turns per section being twice as many. We see, therefore, that, all other things being equal, the propensity to sparking is twice as great for ring armatures as for drum armatures at equal size of sections of the commutator—*i.e.*, for small machines.

When the size of the dynamos increases, the contrary occurs; it happens, indeed, at the position when only one turn per section is used, and if the size of the dynamo, and consequently the magnetic flux, increases still more, the number of sections must be diminished.

For electrolytic dynamos giving 20 to 30 volts we very rapidly reach this state, even for machines of low power. Here it is the voltage desired which determines the number of sections, and not mechanical considerations, and we see that for the same voltage we shall have twice as many sections for ring winding as with the drum winding; and for the variation of current from $\frac{C}{2}$ to $-\frac{C}{2}$ in the section under the brushes the variation of flux in its current will be:

For drum armatures, $\alpha\,F\,C$,

and for ring armatures, $\alpha\,\frac{F}{2}\,C$.

The propensity to sparking will thus be only half as great for ring as for drum winding.

For large two-pole machines the considerations of voltage limit the number of sections in the armature; ring winding will be preferable because it gives twice the number of sections.

We will now consider four-pole machines. We have here the choice of several windings:

1. Simple ring winding with poles connected in parallel with four brushes at the commutator; or else two brushes only and a connector.
2. Ring winding in series—*i.e.*, connecting in series the sections placed similarly under poles of the same name. This winding can be employed without connector (Fritsche system).
3. Drum winding with the poles in parallel (Thury).
4. Drum winding in series (Fritsche, Thomson, etc.).

As for the two pole machines, we have here also to distinguish several cases. In the first place, the small machines with several turns per section, and the large machines with only one turn per section, the number of sections being limited by the voltage required.

The propensity to sparking—*i.e.*, the change of flux traversing the circuit of a short-circuited section when the current changes direction—is in the first case:

For drum winding with poles in parallel, C being the current passing through armature, n the number of turns per section, and F the flux on each pole:

$$\alpha\,F.\,\frac{C}{2}\,n^2.$$

With the winding in series, there are twice as many turns per section, but each section will enclose a double flux, and the current which circulates therein will be twice as strong, therefore we shall have

$$\alpha\,2\,F\,.\,C\,.\left(\frac{n}{2}\right)^2 = \alpha\,F\,\frac{C}{2}\,n^2.$$

From the sparking point of view it will therefore appear that these two windings are equal.

For the ring armature we shall have twice as many turns per section. The propensity to sparking will be therefore expressed by the expression:

$$\alpha\,F\,C\,n^2.$$

Both for winding in series and in parallel, the sparking propensity in the ring will thus be twice as great as for drum winding.

For large dynamos where only one turn per section can be used we shall have twice as many sections in the ring armature as for the drum, and twice as much for parallel winding as for series winding.

To bring all this into practical shape, I have calculated for various dynamos built by M. Postel-Vinay; and the numerical values given by the formula coming out remarkably well, I have found by determining for each machine α, according to the characteristic:

For a dynamo of 100 volts and 10 amperes, with a flux

* From *L'Electricien.*

of 640,000 and nine turns per section, drum winding, and a = 4,000:

129,600.

For a dynamo of 8,800 watts, 110 volts with F = 2,700,000, two turns per section, drum winding, and a = 8,000:

108,000.

For a dynamo of 20,000 watts, 120 volts, F = 5,000,000, one turn per section, drum winding, and a = 12,000:

75,000.

For a dynamo of 30,000 watts, four poles, 120 volts, F = 5,000,000 per field magnet, one turn per section, drum winding, poles in parallel, and a = 10,000:

68,000.

These figures are very low; usually they are much higher. But it is to be noticed that these figures are all of the same order; they vary much less amongst each other than the power of the dynamos. The highest figure is for the small dynamos of 1,100 watts, and as a matter of fact it was this machine whose regulation was most delicate; while for the large machines of 20,000 watts a change of load to the extent of 50 per cent. could be made without causing sparking.

(To be continued.)

WESTINGHOUSE ARMATURES.

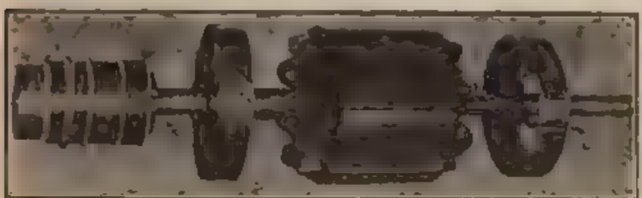
We gave last week a general description of some of the best-known forms of Westinghouse dynamos. We wish to supplement that article by a more detailed description of the Westinghouse armatures.

The armature of a dynamo is a complicated piece of machinery. Composed of thin plates of iron, strips of insulated copper, layers of mica and bronze commutator segments all kneaded, as it were, together, and often held by curious devices of clamping rather than real mechanical arrangements, the ordinary armature has been not inaptly compared to "a bundle of wires on a stick." To overcome these engineering ineptitudes has long been the endeavour of electrical designers, and not the least successful in this direction have been the Westinghouse Company, whose very mechanically-built armatures we illustrate in several different types.

The general aim in these armatures has been to secure (1) solid driving of the coils, (2) that the coils should be lathe-wound beforehand, and (3) that the armatures shall be smooth faced, with no wire capable of injury on the outside; at the same time they are so arranged as to enable any damaged coil to be quickly taken out and replaced without the necessity of changing the whole armature.

Alternate Current Armature.

Alternate-current generators are constructed in which the fields are excited in part from separate exciters and in part by current from the dynamo itself. They are also



Westinghouse Toothed Armature.

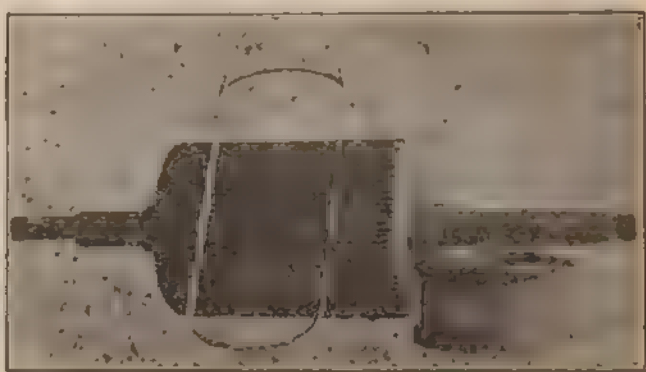
made entirely self-exciting, though the former plan is preferred for station work, or where great variation of load is expected. The exciting current from the dynamo is directly proportioned to the total armature current at all times, so that when it is fully loaded it will have maximum field. To maintain normal constant pressure in the mains, the external exciter current is fixed, and the internal exciter current varies the field to maintain constant potential under change of load.

The method of composite winding employed for this purpose is made simple by the use of a toothed armature. The armature is hollow, to allow of ventilation, and is built up of thin steel discs having T-shaped teeth on their peripheries. These discs are placed side by side, and clamped by rigid end plates. All the coils are lathe-wound, prepared previous to fitting, insulated with cotton

Toothed Armature and Coil.

and prepared tape. The coils are one by one slipped over the teeth, and pressed into place on the armature. It will be seen in the photograph that one of the coils has been slipped over one of the teeth, and a screw compressing arrangement is applied to the end of it. This squeezes the coil and forces it under the teeth, thus entirely surrounding the coils with iron. Wooden wedges are then driven in between adjacent coils, serving to keep the coils absolutely tight and to prevent noise through the armature teeth beating the air.

The armature thus constructed has no wire whatever on the outside of the toothed armature. It can be handled with ease, and even rolled along the floor without the

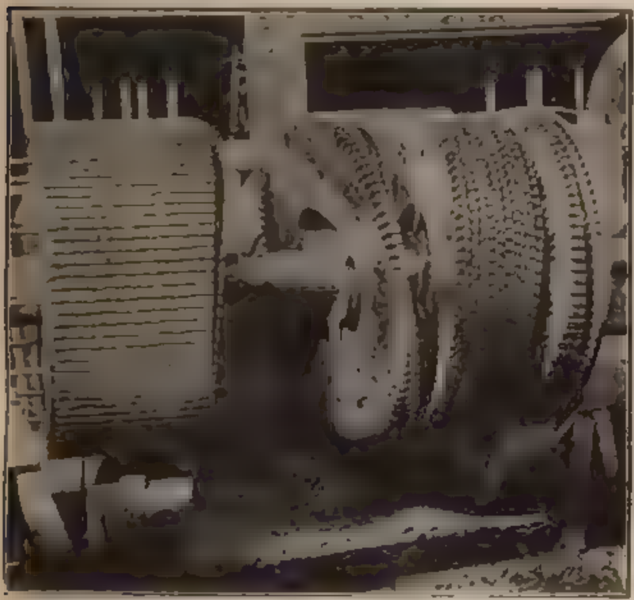


Street Car Armature and Coil.

least danger or injury. The enormous advantage of this can only be appreciated by the central-station engineer who has suffered delays and expense from the injury of surface-wound armatures. An increased clearance is also obtained, and will allow for greater wear of bearings, without appreciable extension of the distance between the iron of armature and the pole-pieces.

There is still another advantage claimed for these tooth-wound armatures. The chance of a burn-out cannot be entirely eliminated in station work. The burn-out is caused by the rush of current when the resistance at the

terminals is removed or suddenly lowered. Now, with the toothed armature an element is introduced which reduces this difficulty. By reason of the proportions of iron and copper used, and their arrangement with regard to each other, a transformer action is brought about for the creation of a high counter E.M.F. whenever excessive current tends to pass. Without defining the arrangement more exactly, the result may be mentioned: on short circuit, while the dynamo current increases in quantity to five times its normal amount, the E.M.F. simultaneously decreases to about one-fifth of its normal. The total dynamo output is approximately the same, and there is no burn-out or throwing off of belts. This method of winding is patented by the Westinghouse Company.



Direct Current Armature Discs.

We show two other methods of winding drum armatures: of the direct-current railway generator, and the corresponding motor armature.

RAILWAY MOTOR ARMATURE.

In the case of the motor armatures, as before, each coil is wound on a lathe, and is finished, insulated, and complete before being put on the armature. The simplicity of this method is apparent—the armature winder has simply to slip the completed coils into position. He does no handling of the individual wires, nor can he make any mistake as to the size of coil; and the judgment of the winder is not depended on for the efficiency of the insulation. The coils are bent to the special form shown, and simply placed in position, bound down, and their ends connected to the commutator.

Motor Armature and Coil.

Each coil is tested to stand 2,500 volts, and this is repeated when the winding is finished. This is five times the normal voltage of railway motors. Mechanically, the coils are held rigidly in the grooves punched in the discs, and no shifting of position is possible when starting under heavy load. To protect the armature outside, the insulation is bound over with band wires, not necessary to hold the coils, which are fixed in the grooves, but as added protection, and to render the surface smooth and ship-shape. The various stages of winding of motor armatures are shown in the illustrations.

TWO-CIRCUIT WINDING FOR MOTORS.

The method of connection is that known as the two-circuit winding. This winding, used in conjunction with a toothed armature, gives numerous advantages.

Direct-Current Generator Armature.

Though using a four-pole field, there are only two paths for the current, and two brushes only are preferred. One portion of the armature cannot carry more current than the rest, which, in ordinary armatures, sometimes happens from accidental change of position as regards the pole-pieces through wear of bearings. No high-tension wires cross each other, and there is no piling up of wires on the shaft. At the same time, the armature is small in size, accurately balanced, and solidly constructed. The drum armature, being directly keyed to the shaft, is truly centred, and no non-magnetic spider is required. The great difficulty with these spiders is the variation of coefficients of expansion of the bronze and the iron of the core, and the constant expansion and contraction tends to make the spider work loose. But it is essential that the armature core should be rigidly connected to the shaft, and should remain so under all changes of load; this renders a drum armature preferable, as rigid connection can only be secured by the use of the drum. There remains the question of circuit connection.

Motor Armature in Different Stages.

Engineers have been divided in opinion as to the advantages of four-pole and two-pole motors. The four-pole field is cheaper and has less magnetic resistance, and allows the use of a circular yoke, which is lightest and strongest for a given weight. But the two-circuit armature is preferable from the electrical point of view. The Westinghouse motor combines these two forms, obtaining the advantages of both types of machines.

DIRECT-CURRENT GENERATOR ARMATURE.

The railway generator armature, for continuous-current work, is built of large discs in the same manner as before

described, but in this case holes are punched in each disc, and the method of winding consists in simply threading thick wires, suitably insulated, one by one through these holes in the armature core and laid in the parallel slots, afterwards connecting them up to the commutator singly afterwards. In this case, of course, the coils are not "lathe-wound."

The armature is of the drum type, and is built up as shown. The method of winding and connecting to the commutator is similar to that used in the motor. The armature has only two circuits, and two or more brushes may be used. For the sake of proper collection of current four sets are used with the four-pole machine and six with the six-pole machine, since there is no inconvenience of having more brushes on a generator.

The two-circuit winding, as before, makes the armature circuits perfectly balanced. Eddy currents are obviated by preventing the wires from cutting the lines of force in the air-gap; this is managed by sinking the conductors below the surface. The lines of force then pass through the iron teeth, and the wires are shielded from eddy currents.

One great desideratum in railway generators is that there should be no change of lead from no load to full load, as change of lead means sparking. In order to prevent this the field must be at all times strong enough to overcome the reactive magnetism of the armature. In other words, the ampere-turns in the armature must be kept low. This is obtained by using a two-circuit winding in conjunction with a drum armature, with a minimum of conductors—one turn of wire per commutator segment. The wires are of large section, and carry the current efficiently and without undue heating.

This armature is not liable to mechanical damage from short circuit, as surface-wound armatures too often are, the sudden rush straining the connections to bursting point. Tests have been repeatedly made at the works by short-circuiting the generators without the slightest injury. This speaks exceedingly well for the Westinghouse armature.

The armature is evidently accurately balanced, and the insulation is of the highest kind. The insulation on each wire is tested to 10,000 volts alternating before passing the machine. Nor are there any high-tension wires crossing or touching each other, a great advantage, impossible to achieve with the ordinary drum. No two adjacent wires have a greater difference of potential than the two adjacent commutator bars. Finally, in this armature any wire can be replaced without disturbing the rest or removing the armature from the fields.

The great experience the Westinghouse Company have had in electric railway motor and generator work has enabled them, it will be seen, to produce electric machinery of the best type, thoroughly practical, and of sound mechanical design. The details we have given of their armature construction will, we think, be found of considerable interest to electrical designers and engineers.

GEOMETRICAL PROOF OF THE THREE-AMMETER METHOD OF MEASURING POWER.*

BY FREDERICK BEDELL AND ALBERT C. CREHORE.

The methods now well known for measuring power by three voltmeters or three ammeters, first shown by Prof. Ayrton and Dr. Sumpner,† are applicable to the measurement of power of any circuit irrespective of the nature of the impressed E.M.F., and the general proof of the methods is given in the paper referred to. In the case of an harmonic E.M.F. the methods are capable of simple geometrical proof. The writers have shown this‡ for the voltmeter method, and in this note will give the corresponding proof for the three-ammeter method.

Let R_2 L_2, Fig. 1, be an inductive circuit whose power is to be measured, and R_1 a non-inductive resistance in parallel with it. If the maximum values of the main and branch currents be denoted by I, I_1, and I_2 respectively, they may be represented as shown in Fig. 2. The current I_1 is in phase with the impressed E.M.F., E; the main current, I, lags behind it by an angle θ; and the current I_2 lags behind it by an angle θ_2. The tangent of θ_2 is $\frac{L_2\omega}{R_2}$; and the tangent of θ is $\frac{L'\omega}{R'}$, where R' and L' denote the equivalent resistance and self-induction of the parallel circuit*, and ω is 2π times the frequency.

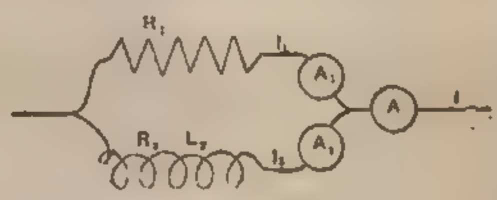


FIG. 1.

The power expended in the inductive circuit is $W_2 = \frac{1}{2} E I \cos \theta_2$. From the geometry of the figure,

$$\cos \theta_2 = \frac{I^2 - I_1^2 - I_2^2}{2 I_1 I_2};$$

whence

$$W_2 = \frac{E}{4 I_1} (I^2 - I_1^2 - I_2^2),$$

where E, I, I_1, and I_2 represent maximum values. Writing virtual or square root of mean square values as obtained from ordinary measuring instruments, the expression for the power becomes:

$$W_2 = \frac{\bar{E}}{2 \bar{I}_1} (\bar{I}^2 - \bar{I}_1^2 - \bar{I}_2^2).$$

The power in the non-inductive branch is

$$W_1 = \bar{E} \bar{I}_1;$$

and the total power in the two branches is

$$W = \frac{\bar{E}}{2 \bar{I}_1} (\bar{I}^2 + \bar{I}_1^2 - \bar{I}_2^2).$$

The method is thus geometrically established for harmonic currents, which may be represented by lines in a

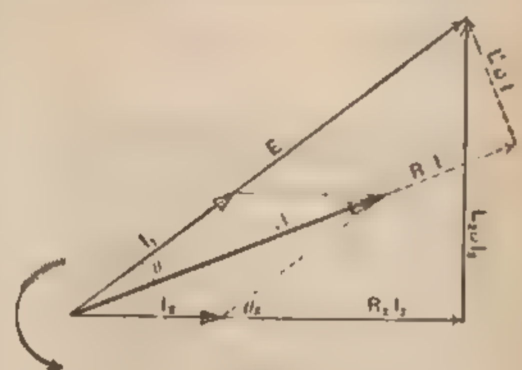


FIG. 2.

vector diagram. For an alternating current not harmonic the proof does not hold unless we assume the current to be equivalent to an harmonic current, and the question then arises as to what will be the equivalent harmonic current. The equivalent harmonic current must be such that its square root of the mean square value, and the expenditure of energy in the circuit, are the same as in the case of the given current which was not harmonic.

Fire Alarm.—An automatic fire alarm has been brought out by the Stettin Electricity Works for use in buildings. It is based upon the expansion by heat of air in a closed box, and which expansion completes the circuit and causes a bell to ring and a figure to indicate the number of the room in which the fire may have broken out.

* From *Physical Review*, July August, 1893.

† "The Measurement of Power given by any Electric Current to any Circuit." –*Proceedings*, Royal Society, vol. xlix., p. 424.

‡ "Alternating Currents," p. 230.

* "Equivalent Resistance, Self Induction, and Capacity of Parallel Circuits with Harmonic Impressed Electromotive Force." Bedell and Crehore, *Phil. Mag.*, September, 1892.

THE NATURE OF DEPOLARISERS.*

BY HENRY E. ARMSTRONG.

I am induced to somewhat extend my recent note on depolarisers in order that the argument there made use of in considering the dissolution of metals such as magnesium in nitric acid may be clearly understood, and its consequences more fully realised.

It is one of the most noteworthy features of such interactions that when reduction is carried beyond the nitric oxide stage, it invariably proceeds to ammonia, and gives rise to a variety of products: so that whereas neither nitrous oxide nor nitrogen is evolved when metals such as silver and mercury are dissolved, these two gases are always obtained when more active metals are the agents From this it would appear that there is a limit of (?) E.M.F. which must be exceeded if it be desired to extend the reduction beyond the stage involving the formation merely of nitrogen dioxide and monoxide.

A somewhat similar case is presented by the behaviour of sulphuric acid solutions on electrolysis. Whereas, besides hydrogen, only oxygen is obtained under certain conditions, under others ozone, persulphuric acid, and hydrogen peroxide are also produced. This apparently is a phenomenon of the same order, but in a measure the converse of that presented by nitric acid, as oxygen—not hydrogen—is the active substance. Judging from McLeod's observations (C.S. *Transactions*, 1886, 591), it is clear that "current density" is an all-important factor in determining "peroxidation," but it remains to be determined whether it is the sole factor: the individual influence of E.M.F., of current strength and of current density, in fact, all require careful study in this as in many other cases of electrolysis; undoubtedly much depends on the concentration of the acid. The peroxidation may be regarded as the outcome of oxygen depolarisation, effected apparently in two ways: part of the oxygen becoming affixed to sulphuric acid, persulphuric acid is formed, which in part gradually undergoes hydrolysis, affording hydrogen peroxide—a non-electrolytic change; while another part serves as oxygen depolariser, affording ozone. On this assumption, ozone is not the product of the fortuitous concourse of three oxygen atoms, but of the interaction of oxygen atoms in circuit with persulphuric acid; and if this be the origin of electrolytic ozone, it appears not improbable that the oxidation of phosphorus, which is attended by the formation of ozone, will also be found to involve the formation of a peroxide hitherto undiscovered.

In the case of a metal such as magnesium dissolving in considerable excess of nitric acid, if a plate be imagined to be undergoing attack and conversion into nitrate at any one point, the displaced hydrogen may, it would seem, "travel along" a very large number of paths to other points on the plate capable of acting as negative pole and of there meeting with nitric acid in sufficient amount to oxidise it, and it is scarcely conceivable, therefore, that it should escape if the nitric acid act directly as depolariser. It is also difficult to understand why one substance—an electrolyte—should act in two ways in the same circuit, and the difficulty appears to be equally great, whether any form of Grothus's hypothesis, or a dissociation hypothesis, be adopted in explanation of electrolysis. But these difficulties seemingly disappear if—as previously suggested—the active depolariser be a nitrous compound or derivative; perhaps, at all events, at the initial stage, nitrogen dioxide. Moreover, it would appear to be possible in this manner to account also for the extension of the reduction to ammonia: in the case of a metal like silver the amount of depolariser must always tend to reach a maximum value depending on the extent to which the reversible interchange expressed by the equation $NO + 2HNO_3 = 3NO_2 + OH_2$ is limited by the concentration and temperature; but it is limited by these conditions alone. In the case of more active metals, it appears probable that the nitric oxide also functions as depolariser and is reduced to hydroxylamine and ultimately to ammonia. If such an action take place, it follows (from Ohm's law) that the more active the metal the more rapidly will hydrogen be displaced by it, giving greater opportunity, therefore, for nitric oxide to undergo reduction and leading to the production of an increased proportion of products of extended reduction. Any circumstance which would tend to diminish the proportion of nitrogen dioxide relatively to monoxide present in solution would therefore promote the formation of such products, and, in point of fact, Acworth and I have noticed, even in the case of copper, that when the metal is dissolved in diluted nitric acid, it appears to be more "active"—*i.e.*, to furnish a larger proportion of products of extended reduction—than when more concentrated acid is used; as the presence of water must obviously favour the reversal of the interchange expressed by the equation $NO + 2HNO_3 = 3NO_2 + H_2O$, so that weaker would potentially contain a larger proportion of monoxide than stronger solutions of nitric acid; these observations would appear to be in harmony with the hypothesis here advocated. There is no evidence, be it remarked, that hyponitrous acid can be formed in acid solution—*i.e.*, by direct reduction of nitric or even of nitrous acid; and the whole of the nitrous oxide which is evolved when metals are dissolved in nitric acid may result from the interaction of nitrous acid and hydroxylamine. That reduction invariably extends to ammonia whenever hydroxylamine is formed is probably a consequence of the extreme readiness with which hydroxylamine is itself reduced, so that, in fact, when reduction once proceeds beyond the nitric oxide stage, it is to be supposed that there are necessarily a number of competing depolarisers present in solution—nitrogen dioxide and monoxide and hydroxylamine and, perhaps, others—none of which, however, are electrolytes in the sense in which the term is ordinarily understood. And here it may pointed out that the fact that a nitrate may be reduced in alkaline solution by sodium amalgam, or aluminium, or zinc, is no argument against the conclusion above arrived at that probably nitric acid does not directly act as depolariser, as in these cases the alkaline solution appears to be the electrolyte, and the nitrate merely the depolariser, so that the nitrate does not act in two ways. As nitrates may be wholly converted into ammonia by reducing an alkaline solution, it would seem probable that in such cases hydroxylamine is not an intermediate product, as nitrogen is obtained on boiling an alkaline solution of this substance.

The argument here made use of would appear also to afford an explanation of the effect produced by varying the E.M.F.—*i.e.*, by metals of different degrees of "activity"—as increase of E.M.F., other conditions remaining unchanged, would increase the current strength, and consequently the rate of change; and, as indicated above, an increase in the rate of change would doubtless involve an increase in the amount of products of extended reduction.

It remains to be pointed out that the objection made to the assumption that nitric acid can act in two ways is equally applicable to the case of sulphuric acid; in other words, that it is not likely that sulphuric acid would act as electrolyte and as oxygen depolariser. It becomes necessary, therefore, to reconsider the manner in which solutions of this acid undergo electrolysis. On the one hand, it is conceivable that the water molecule alone suffers partition, not the sulphuric acid (H_2SO_4) molecule, as commonly supposed, and that under certain conditions the latter takes a direct part in the change, becoming oxidised; but this does not appear to be probable, especially as there is reason to believe that the acid in conjunction with water actually functions as electrolyte. An alternative assumption would be that the immediate product has been overlooked, and it can scarcely be gainsaid that there is much evidence in favour of this view. It is not improbable that the first products of electrolysis are hydrogen and persulphuric acid; it may be supposed that under "ordinary" circumstances this latter substance is resolved at the electrode surface into oxygen and sulphuric acid, but when the electrode surface is small much escapes unchanged, this being especially the case when the electrolyte is a somewhat concentrated acid—a condition which in itself favours the survival of persulphuric acid. Not only do recent observations on the electrolysis of various sulphates support this contention, but it would seemingly also explain the extraordinary character of the curve representing the change in conductivity of solutions of sulphuric acid on dilution.

* From the *Proceedings* of the Chemical Society.

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CONTENTS.

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ELECTRIC LIGHT IN LIGHTHOUSES.

We have received an interesting document which may be taken to embrace the evidence obtainable against the use of electricity for lighthouse purposes. It has often struck us that the future historian will have a hard task in deciding the truth of matters relating the end of the nineteenth century. If necessary, evidence can be produced for or against anything. There seems to remain not a single instance of desire to tell the truth, but on every hand the aim is to lie as bravely as possible in the interests of *our* side. With this object in view, it is easy to get testimonials in favour of electricity, or gas, or rushlights. You have only to ask a sufficient number to testify, and choose your sentences. Most people take sides nowadays, and if we want signatures in favour of felt hats we know where to go — as against straw hats, or in favour of whisky against Hollands. So this evidence respecting the electric light as a lighthouse illuminant—it is all very well till the other side interested produces its evidence. This is against the electric light, which is condemned because of "its intense and blinding effects," its not showing "so far in hazy weather," its easier obscuration by "fog," by "thick weather"; its brilliancy misleading mariners as to their "distance from it." The opinions, in fact, run in these two forms — "its misleading properties," "its obscurity in fog, hazy, and thick weather." Of course it is said to be worse, "far worse than oil or gas light." It is dazzling and unsteady. One captain says: "I am sure the new light will pierce fog far better than the electric light," which points to the view that this evidence has been collected by someone who has to push a "new light," be it gas or of oil. Another captain says: "I am of the same opinion as I have ever been—that the electric light for lighthouse purposes is a delusion and a fraud on the sailor. I nearly lost my life on Dungeness Point when the electric light was put there. The Trinity House yacht, Captain Wallace, got on shore there—so much for electricity." Prof. Tyndall is cited as against electricity and in favour of Wigham's light, as is Mr. Vernon Harcourt, who gives a reason for the obscuration of the electric light by fog, that "when a fog came on most of the violet rays were absorbed, leaving only the red. Therefore, the effect of the fog would be to cut off most of the violet rays, and leave a proportionately small number of red rays. In the case of oil and gas there was, of course, a similar diminution, but there was not the same loss, because the red rays were not nearly so much absorbed. It would be seen, therefore, that there was a great loss of intensity in piercing fogs with the electric light as compared with gas. It was a question whether in such a case it was worth while to use a light of such a high intensity, if a light with a lower intensity could be employed with equal advantage in fogs. The great point in lighthouse illumination was whether the light could pierce the atmosphere in foggy weather, there being quite light enough in ordinary weather. It appeared to him that it would be far better to use a gaslight of 5,000 candles, and to improve the appliances and,

if possible, the illuminating power of gas and oil lights, than to use the electric light for a purpose for which it was not suitable, so long as it was developed from carbon points." Now, Mr. Vernon Harcourt is a great authority, but we protest against a portion of this statement—that referring to the greater absorption of certain rays. Quotations are made from the paper of Cav. Dominico Lo. Gatto, read at the recent International Maritime Congress, but we are under the impression that Cav. Gatto stated at the congress that his views were considerably modified during the discussion at the congress. Hence, unless the quotations used have been since agreed to, they should possess no weight.

Let us admit that there is something in all this evidence; admit the whole as true if you like. What then? In the first place, it would mean certain alterations in the electrical apparatus to put it upon an equality with gas or oil. It is not impossible to so adulterate your carbons to give different coloured rays rays that are not liable to so great absorption; in the second place, you can easily make your light less brilliant, but so far as this part of the evidence is concerned, it is all moonshine. The only part worthy of discussion is the less effectiveness in fog, which arises, according to the critics, from the concentration of light too much at a point—a property which can be obviated—and the absorption of certain rays, which again can be obviated. We have never heard that electric light engineers possessed any influence to cause its adoption as against gas or oil. History seems to say that electricity was only adopted upon the advice of competent advisers. The conclusions of the advisers may have been wrong, but no one has yet attempted to get the evidence in favour of electricity, and till that is done no one is able to judge of the correctness of these conclusions.

"PRESSURE" OR "TENSION"?

Webster defines "tension" in seven different ways. When the word is used electrically, Webster says it means "The quality in consequence of which an electric charge tends to discharge itself, as into the air by a spark, or to pass from a body of greater to one of less electrical potential. It varies as the square of the quantity of electricity upon a given area." Various writers in the *Times* have been calling attention to the misuse of words, generally words which have been taken by us from the French. That shows how language is constantly being made. Thus, a writer wisely says "menu" is not a substantive—it is an adjective, and only in its Anglicised use is it made a substantive. Well, no doubt that is so, but the opinion may be ventured that a hundred years hence will see "menu" acclimatised in English dictionaries as a substantive with a pretty definite meaning. The ordinary run of men—foolishly, no doubt—seldom trouble about pure grammatical forms or dictionary meanings—it is sufficient for them if their hearers understand exactly what they mean. "Carte" may be good French, yet "menu" may be good English. We forget what writer it was who first said that English was such a wonderful language that it had no two words exactly synonymous; so that if a man really troubles about accuracy, he cannot well make a mistake. We are not much troubled about philologists or grammarians so far as the words in common use among electrical engineers are concerned. The redundant words will, in the nature of things, be gradually lost, and the words retained will be concreted in meaning. There seems at present to be a fight between the use of "pressure" and "tension." Which word is to be preferred in dynamic electricity? Originally the meaning of tension as given by Webster was undoubtedly obtained from the study of static electricity, and might now be approved in this use by engineers when considering what goes on, or is supposed by modern scientific men to go on, in the dielectric when a static charge is considered. The ordinary engineer approaches the use of electric apparatus from another standpoint. He is told that electrical science has many analogies in hydraulics, and at once an important factor is the action attributed to "difference of potential," which he proceeds to call "difference of pressure," and thus uses the word "pressure" to indicate, if we may so term it, the actuating force of an electric circuit. In ordinary correspondence one half the writers use "pressure," the other half "tension" to mean the same thing. What system do you use? The answer is just as likely to be "high or low pressure" as "high or low tension," and according to the doctrine of probabilities the betting is even upon either word. Perhaps the tendency is towards "pressure." It would be well to come to a decision upon the subject, as the philologists—if anyone cares about them—of 1993 may worry considerably over the difference in meaning between "tension" and "pressure," so indiscriminately used in the literature of the end of the nineteenth century. So far as we are concerned, a word may be coined by taking half-a-dozen letters from a hat so long as it is universally adopted, but we are confident that some objector would within a fortnight come along and propose something else, and reintroduce the confusion. It is the same all round. In the earliest days it was the "incandescent lamp," and "incandescent" it generally remains, though a few, to show their infinite superiority, use the term "glow lamp." It matters not—"a rose," etc.—but surely we might make an attempt at uniformity. Chicago will, perhaps, settle all.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ACCUMULATOR TRACTION.

SIR,—We never anticipated that a gentleman interested in overhead traction would advocate accumulators, and therefore Mr. Sellon may set his mind at rest and not trouble about any uneasiness which his remarks may cause us.

One of the possible reasons why the cost on the Bristol-road is higher than on any other line worked by the Birmingham Central Tramways Company is modestly hinted at by Mr. Sellon himself, and he will no doubt be pleased to learn that the management of the tramway company themselves are quite aware that a considerable reduction in the working expenses on the accumulator lir

can be effected, as will be seen on perusing Mr. Ebbsmith's remarks at the last meeting of the shareholders to the effect that "the Central Tramways was encouraged to proceed with the negotiations which had been held in suspense, and which the Board, after careful consideration by the engineers, were encouraged to believe would mean a profit to the company upon that line of not less than £2,000 per annum." For Mr. Sellon's edification we would like to add that we have pointed out to the tramway company several sources of undue expenditure which can easily be guarded against, and that we have offered them to work the line at a price considerably below the present one.

That the installation of any line on the accumulator system effects a saving of about 40 per cent. as compared with any other system in which the current is conveyed from a long distance, and that the working of such a line by means of accumulators can be effected at a lower rate per car mile than by any direct system, can in the face of such facts as exist only be ignored by those who are desirous not to be convinced.—Yours, etc., L. EPSTEIN.

REVIEWS.

Griffin's Electrical Engineer's Price-Book. Edited by H. J. DOWSING, M.I.E.E., etc. London: Charles Griffin and Co.

Builders and engineers have long had their price-books. An examination of these books will show that during the past few years as new editions were published a section has been devoted to electrical apparatus. The information given therein is necessarily meagre and incomplete, so that a price-book devoted solely to electric apparatus will be welcomed by all in the trade. For a first edition this book of Mr. Dowsing's seems exceptionally good. Great care has evidently been taken in the arrangement and selection of apparatus, and besides the price-list proper each section is prefaced by valuable information of a general character, relating, however, to the apparatus priced in that section. The great value of a price-book depends upon (1) correctness of prices; (2) ease of reference; and (3) selection of subject-matter. The correctness of prices means a laborious examination and analysis of manufacturers' latest price-lists, as does also the selection of subject-matter, though the latter also requires an extensive knowledge of the requirements of the case. All price-books tend to give too much. There are items priced which are not referred to once in the lifetime of the edition, and such items being generally of special apparatus seldom used, as a rule vary in price between the birth and death of an edition. In electrical matters it is as yet, however, doubtful what will be largely used and what will be seldom used, so that it is erring on the safe side to make the list as full as possible. For ease of reference in future editions, no doubt the index will be largely extended. Taking this book of Mr. Dowsing's as a whole, he has produced an exceptionally good work of reference, and so far as we can test by dipping into its pages at random, it is accurate. The type and figures of the book are excellent; but if a suggestion applicable to all such books might be made, it would be that every alternate line of figures should have a different face. The composition would be more costly, but it would be far easier for the reader to keep the lines distinct when making his reference. Printers are very averse to change, but they are studying more and more the wishes of readers. Altogether, this book approaches what may reasonably be expected as regards the specified requisites, accuracy, ease of reference, and well-selected matter, and we congratulate Mr. Dowsing upon his successful labours.

ELECTRICAL SYMBOLS AND NOMENCLATURE.*

The following communication has been addressed by Drs. Bedell and Crehore to Mr. A. E. Kennelly, member of the Committee on Provisional Programme, appointed by the American Institute of Electrical Engineers for the World's Congress of Electricians.

Sir,—In accordance with the suggestion made by you in a recent conversation on the subject of electric symbols and nomenclature, the system of notation given below has been tabulated by us and is offered as possibly including some material which might be incorporated into a uniform international system of terminology and abbreviation which will doubtless come up for discussion at the World's Congress of Electricians near at hand. The carefully-worked-out scheme of M. Hospitalier is a valuable foundation for a suitable system, and the following table has been made upon it as a basis, in conformity with it in the main, with such amendments and additions as seem advisable. In order that a comparison with the proposal of M. Hospitalier may be the more readily made, his system has been placed in a parallel column with the one now suggested.

Physical quantities.	Symbols.	Defining equations.	System of M. Hospitalier.
Fundamental.			
Length	L, l, r	......	L, l
Mass	M	......	M
Time	......	......	T, t
— definite period	T	......	—
— independent variable	t	......	—
Geometric.			
Surface area	A	$A = L^2$	$S = L.\,L$
Volume	V	$V = L^3$	$V = L.\,L.\,L$
Angle	a, θ, ϕ	$a = \frac{\text{arc}}{\text{radius}}$	$a = \frac{\text{arc}}{\text{radius}}$
Number of windings	S	......	N
Mechanical.			
Velocity	v	$v = \frac{l}{T}$	$v = \frac{L}{T}$
Angular velocity	ω	$\omega = \frac{v}{r}$	$= \frac{v}{L}$
Acceleration	a	$a = \frac{v}{T}$	$A = \frac{v}{T}$
Force	F	$F = M.\,a$	$F = M.\,A$
Work	W	$W = F.\,l$	$W = F.\,L$
Power	P	$P = \frac{W}{T}$	$P = \frac{W}{T}$
Pressure	p	$p = \frac{F}{A}$	$p = \frac{F}{S}$
Moment of couple	(?)	$= F.\,l$	$W = F.\,L$
Moment of inertia	K	$K = M.\,l^2$	$K = M.\,L^2$
Magnetic.			
Strength of a pole	m	$F = \frac{m.\,m'}{r^2}$	$F = \frac{m^2}{L^2}$
Magnetic moment	$\mathfrak{M}$	$\mathfrak{M} = m.\,l$	$\mathfrak{M} = m.\,l$
Intensity of magnetisation	$\mathfrak{I}$	$\mathfrak{I} = \frac{\mathfrak{M}}{V}$	$\mathfrak{I} = \frac{\mathfrak{M}}{V}$
Field intensity	......	——	$H = \frac{F}{m}$
Flux of magnetic force	......	——	$\Phi = H.\,S$
Magnetising force—constant value	H	$\mathsf{H} = \frac{4\pi S I}{l}$	$\mathfrak{H} = \frac{4\pi N I}{L}$
— maximum value when varying harmonically	H	......	——
— instantaneous value	h	......	——
— sq. root of mean sq. value	$\bar{\mathsf{H}}$	......	——
Magnetomotive force—constant value	F	$\mathsf{F} = \mathsf{H}\,l = 4\pi S I$*	$\mathfrak{F} = 4\pi N I$
— maximum value when varying harmonically	F	......	——
— instantaneous value	f	......	——
— sq. root of mean sq. value	$\bar{\mathsf{F}}$	......	——
Magnetic susceptibility	κ	$\kappa = \frac{\mathfrak{I}}{\mathsf{H}}$	$\kappa = \frac{\mathfrak{I}}{\mathfrak{H}}$
Magnetic permeability	μ	$\mu = \frac{\mathsf{B}}{\mathsf{H}}$	$\mu = \frac{\mathfrak{B}}{\mathfrak{H}}$
Specific magnetic resistance (*reluctivity*)	ρ	$\rho = \frac{1}{\mu}$	$\rho = \frac{1}{\mu}$
Magnetic resistance (*reluctance*)	$\mathfrak{R}$	$\mathfrak{R} = \frac{l}{A\mu}$	$\mathfrak{R} = \rho\frac{L}{S}$
Magnetic induction—constant value	B	$\mathsf{B} = \mu\,\mathsf{H}$	$\mathfrak{B} = \mu\,\mathfrak{H}$
— maximum value when varying harmonically	B	......	——
— instantaneous value	b	......	——
— sq. root of mean sq. value	$\bar{\mathsf{B}}$	......	——
Total induction	N	$N = \mathsf{B}\,A$†	——
Electromagnetic.			
Resistance	R	$R = \frac{E}{I}$	$R = \frac{E}{I}$
Equivalent resistance	R'	......	——
E.M.F.—constant value	E	$E = R\,I$	$E = R\,I$
— maximum value when varying harmonically	E	......	——
— instantaneous value	e	......	——

* *Sent to the Electrical Engineer* by the authors.

Physical quantities.	Symbols.	Defining equations.	System of M. Hospitalier.
— sq. root of mean sq. value	$\bar{E}$	....	—
Difference of potential	—	—	$e = \frac{R}{I}$
Intensity of current — constant value.	I	$I = \frac{E}{R}$	$I = \frac{E}{R}$
— maximum value when varying harmonically	I	....	—
— instantaneous value	i	....	—
— sq. root of mean sq. value	$\bar{I}$	....	—
Quantity of electricity—constant value...	Q	$Q = IT$	$Q = IT$
— maximum value when varying harmonically	Q	....	—
— instantaneous value	q	....	—
— sq. root of mean sq. value	$\bar{Q}$	....	—
Capacity	C	$C = \frac{Q}{E}$	$C = \frac{Q}{E}$
Equivalent capacity...	C'	....	—
Electric energy	W	W‡ $= EIT$	$W = EIT$
Electric power	P	P§ $= EI$	$P = EI$
Resistivity	(?)	$= \frac{A}{l} R$	$a = \frac{RS}{L}$
Conductance	(?)	$= \frac{1}{R}$	$= \frac{1}{R}$
Specific conductivity	(?)	$= \frac{l}{AR}$	$= \frac{1}{a}$
Coefficient of self-induction.	L	$L = \frac{N}{I}$	$L_s = \frac{\Phi}{I}$
Coefficient of equivalent self-induction	L'	....	—
Coefficient of mutual induction	M	....	L_m

* More strictly: $\mathbf{F} = \int \mathbf{H} \cdot dl$.

† More strictly: $N = \int \mathbf{B} \cdot dA$.

‡ More strictly: $dw = e\,i\,dt$.

§ More strictly: $P = \frac{dw}{dt}$.

Dashes indicate that symbols are lacking in one system or the other. An interrogation mark (?) has been used to indicate that a symbol is desired. The distinction between maximum values, instantaneous values, and square root of mean square values, thus, E, e, $\bar{E}$, etc., seems called for in alternating-current literature.

Suitable terms for the resistance, real and apparent, in an alternating-current circuit would be extremely desirable; thus:

$$\sqrt{R^2 + \left(\frac{1}{C\omega} - L\omega\right)^2} = \text{impediment};$$

$$\sqrt{R^2 + L^2\omega^2} = \text{impedance};$$

$$R = \text{resistance};$$

$$L\omega = \text{inductance};$$

$$\frac{1}{C\omega} = \text{condensance}.$$

All of these quantities have the dimensions of a resistance and may be expressed in ohms. For the last two quantities, $L\omega$ and $\frac{1}{C\omega}$, suggestive names, as "inductance" and "condensance" are particularly necessary, the terms "inductance speed" and "capacity-speed-reciprocal," already used, being quite cumbersome.

The use of n to denote frequency is already common, and may well be retained. For the quantity $\omega = 2\pi n$ one word, as "rotation" or "rotivity," is needed to take the place of the two "angular velocity."

In conclusion, we would suggest that the word "virtual" be always used to denote the square root of the mean square value of any varying quantity, and that the "effective E.M.F." be used to denote that component of the "impressed E.M.F." which is effective in overcoming ohmic resistance.

FREDERICK BEDELL.
ALBERT C. CREHORE.

Cornell University, July 21, 1893.

In the scheme given above we have used Gothic letters for vector or directed quantities. M. Hospitalier has since explained to us that he does not consider it advisable to introduce this distinction, taking the ground that, inasmuch as the exact nature of all physical quantities is not sufficiently understood to enable a proper distinction to be made in all cases, it would block further progress in this direction to try to introduce this distinction at present. It is, however, open to question whether it is not well to retain the start which has already been made in this direction. The word "reactance," which he has suggested for $\frac{1}{C\omega} - L\omega$, may well be adopted as indicating the presence of a reacting force which is not present in resistance.

F. B.
July 29, 1893. A. C. C.

ON THE TRANSMISSION OF ELECTRIC SIGNALS THROUGH SPACE.*

BY W. H. PREECE, F.R.S.

In the year 1842, Henry showed how the disruptive discharge of a Leyden jar in an upper chamber of his house magnetised needles in a cellar 30ft. below.

In 1884, telegrams sent to Bradford (England), in Morse characters, from the General Post Office, London, through a guttapercha-covered copper wire in an underground iron pipe, buried in the street, were read upon an open telephone circuit consisting of an iron wire carried on poles on the housetops 80ft. away.

In 1885, Mr. Edison showed how it was possible to communicate with a moving train by utilising the electrostatic influence between a circuit erected upon the poles on the side of a railway and a telephone circuit carried by the train.

In the same year, I made many experiments to determine whether the effects observed in England were due to electromagnetic induction, and were quite independent of the earth; and also to find out how far the distance between the wires could be extended before this influence ceased to be evident.

With our ordinary telegraph working currents the region of disturbance reached a distance of 3,000ft., while the effects were detected on parallel lines of telegraph, 10½ miles apart, between Durham and Darlington. Even between the East and the West Coasts at the Border, a distance of 40 miles, currents produced at Newcastle on the Jedburgh line were distinctly heard at Gretna on a parallel line. These latter results, in the North of England, were vitiated by the presence of a large network of railway and other telegraphs between the two places, and as they may not have been due solely to direct electromagnetic induction through space, but to electrostatic effects between neighbouring wires as well, I took a district in the West of England, between Gloucester and Bristol, along the banks of the River Severn, where for a length of 14 miles, and at an average distance apart of 4·5 miles, no intermediate disturbing conductors existed between the pole lines. The valley of the Mersey, and several other localities in England where no disturbing elements existed, were similarly investigated.

It is necessary at the outset to point out that if we have two parallel conductors separated from each other by a finite space, and each forming part of a separate and distinct circuit, either wholly metallic or partly completed by the earth, and called respectively the primary and the secondary circuit, we may obtain currents in the secondary circuit either by conduction or by induction, and we may classify them into those due to—(1) earth currents, (2) electrostatic induction, (3) electromagnetic induction.

It is very important to eliminate (1), which is a case of conduction, from (2) and (3), which are cases of induction.

1. EARTH CURRENTS.

When a linear conductor dips at each end into the earth, with which it makes a good connection, and voltage is impressed upon it by any means, the resulting return current would probably flow through the earth in a straight line between these two points if the conduction of the earth were perfect; but as the earth, *per se*, is a very

* Paper read at the Chicago Exhibition on Wednesday last.

poor conductor indeed (and probably is a conductor only because it is moist), lines of current-flow spread about symmetrically in a way that recalls the figure of a magnetic field. These diffused return earth-conduction currents are evident at great distances.

These lines of current-flow are very easily traceable by means of exploring earth-plates or rods. The primary current is best produced by alternating currents of such a frequency as to excite a distinct musical note on a telephone and if these currents rise and fall periodically and automatically, they produce an unmistakable wail. If they are made and broken by a Morse key, they can transmit readable signals. The secondary circuit, which contains the receiving telephone, is completed, in the case of the earth, by driving two rods into the ground, or, in the case of water, by plates dipping into the water at a distance of from five to 10 yards apart.

In this way the Town Moor, near Newcastle, the sands and the land about Lavernock and Penarth on the coast of South Wales, the water of the Bristol Channel, the towns of Liverpool and Leeds, and London itself, have been thoroughly explored, and it has been proved that the distance to which these lines of flow can be detected depends upon the intensity of the primary current flowing, on the area of the surfaces in contact with the earth, on the resistance of the portion of the earth utilised, and on the dryness of the season. In London the currents working the City and South London Electric Railway affect recording galvanometers at Greenwich, 4½ miles away, and a diagram of the train service on the railway can be recorded in any part of the metropolitan area.

The distance in sea water is not so extensive, for the latter is a better conductor than earth; still, with primary currents of 15 amperes, effects have been traced to one-third of a mile.

In all cases where disturbances have been created by electric tramways they have been shown to be greater in summer than in winter.

(To be continued.)

THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

LECTURE I.

(Concluded from page 154.)

In accordance with what has been above said, it is necessary, when these balances are used for alternating currents, to avoid bringing any metal piece into contiguity with the coils. Accordingly the base of the balance is made of slate, and the coils wound on either slate or porcelain bobbins, or on some material which is a non-conductor. The balance is calibrated for use by means of a steady current, and it is then available for use with alternating currents. Lord Kelvin has devised a whole series of these instruments which are capable of measuring currents from one thousandth of an ampere up to 1,000 amperes, and each instrument has a range of about 1 to 100. The latest pattern of kilo ampere balance is shown in Fig. 6.

A reference has already been made to the electro-dynamometers of Siemens, and before you are a series of these instruments, lent to me by Messrs. Siemens Bros., and which are illustrated in Fig. 7. In all these dynamometers there is a fixed coil and a movable coil, both of which are traversed by the current to be measured. The current is got into and out of the movable coil by means of mercury cups, and the movable coil is brought back to its normal position when displaced by the current by means of the torsion of a spiral spring.

Another instrument of the electro-dynamometer class, but involving a slightly different principle, is one which I devised many years ago, and which depends on the principle of the repulsion of a copper disc by an alternating current. In this instrument there is a fixed coil of wire, which is traversed by the current to be measured. In the interior of this coil of wire there is a small copper disc, which is suspended by a fine wire. The disc is so placed that in its normal position its plane is inclined at an angle of 45deg. to the axis of the corner. When an alternating current is sent through the coil, the copper disc turns round so as to place its plane in the direction of the axis of the coil. The torsion of the wire resists this movement and the copper disc takes up some position of equilibrium. An instrument of this kind can be made to measure very small alternating currents, such as those of about one thousandth of an ampere. Quite recently I have determined the law of deflection of this instrument, and I find that the angular displacement of the disc from its position of equilibrium is

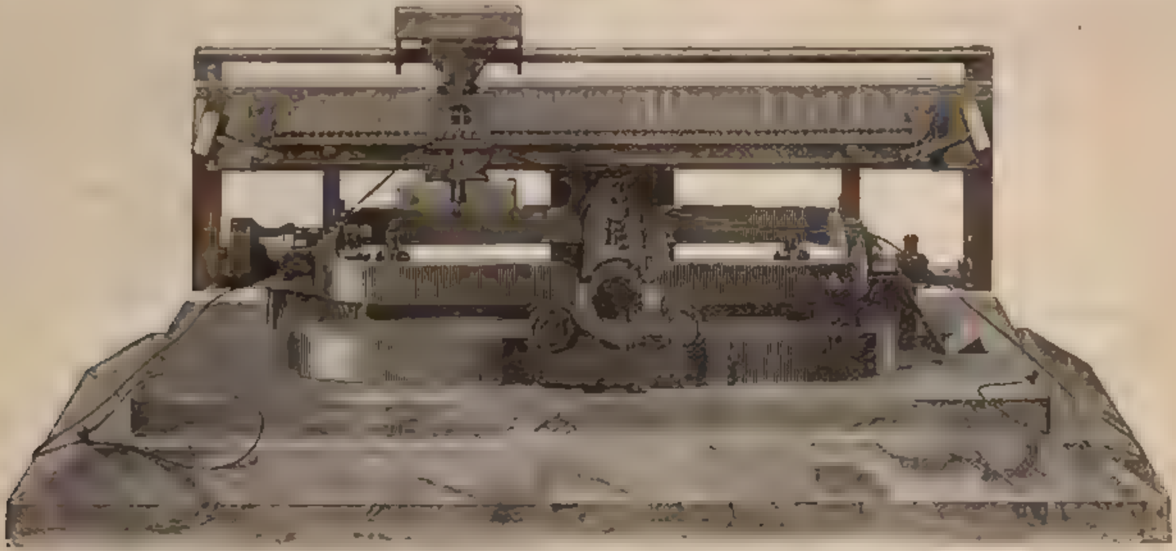

FIG. 6. Standard Kilo-Ampere Balance.

closely proportional to the square of the current strength passing through it. By attaching a mirror to the copper disc, the angular movements can be very much magnified, and the instrument then becomes available for detecting small alternating currents.

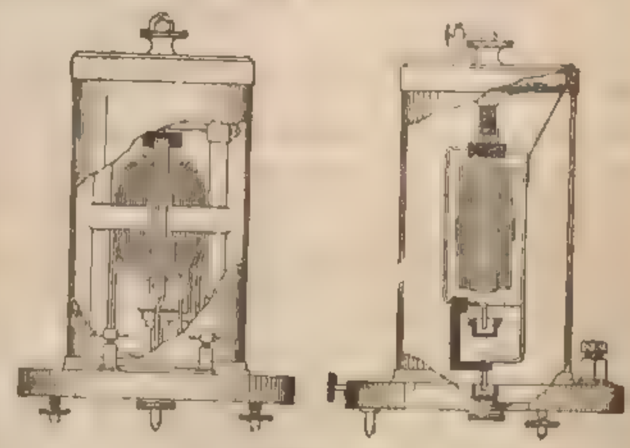

FIG. 7.

We must next pass on to consider instruments which depend on electromagnetic action, and in order to understand the principles on which such instruments act, we must investigate one or two elementary facts with regard to the behaviour of iron in a magnetic field. I have before me a small coil which I will place in a horizontal position in the field of the optical lantern, and in the centre of that coil I suspend a small fragment of iron. You

* Cantor lectures, delivered before the Society of Arts.

see on the screen the shadow both of the coil and the iron. On passing an alternating current through the coil, the piece of iron is drawn away from the centre of the bobbin, and moves up against the side. The explanation of this fact is that a piece of soft iron, when placed in a varying magnetic field, tends to move from places of weak to others of stronger magnetic force, and other things being equal, the force so displacing the iron at any point is proportional to the product of the strength of the field and the rate of change of the field at that point. We may show the experiment in another way. If we place a sheet of glass over the coil and sprinkle on it some iron filings, and then pass a current through the coil, the iron filings all move outwards from the centre of the bobbin to the edge, the reason for this being that the magnetic field of the bobbin is weaker at the centre than it is close up against the wire. This principle is employed in the construction of a large number of instruments. I have before me a selection of Prof. Elihu Thomson's instruments depending on this principle, and which have been lent to me by Messrs. Laing, Wharton, and Down, which are instruments employed for measuring alternating currents.

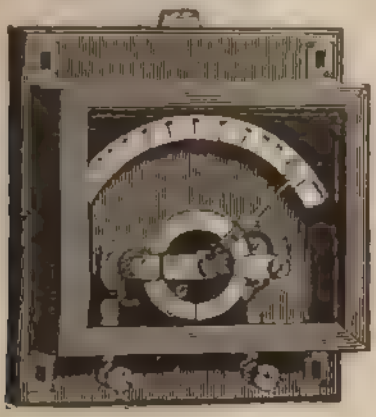

Fig. 8.

In these instruments, Fig. 8, a small plate of soft iron is attached to an axis which passes through the centre of a bobbin in such a manner that if the iron is displaced from the centre to the edge of the bobbin that movement is indicated by a needle. Hence, when an alternating current is passed through the coil, forces are brought to bear on the iron tending to displace it from the centre to the edge of the coil. A weight is so arranged as to resist this movement, and the instrument may be calibrated of different current strengths, and constitutes what is called the gravity instrument, because no springs are used in its construction.

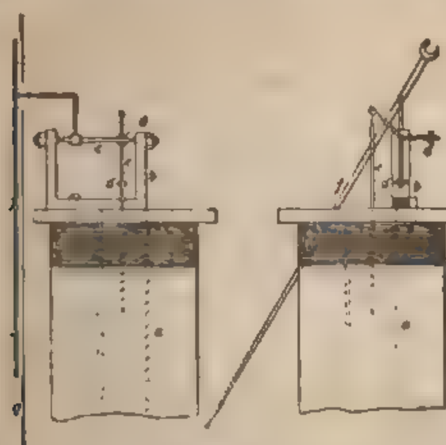

Fig. 9.

Another very similar instrument is that devised by Von Dobrowolsky. In this instrument, which is intended for the measurement of alternating currents, there is a coil of wire, Fig. 9, and in this coil of wire is suspended a very slender fragment of iron wire. When an alternating current is passed through the coil, the iron is drawn down into the coil owing to the tendency it has to move from weak to strong places in the field. This movement of the iron is resisted by the gravity of a small weight. A needle attached to the axis which carries the fragment of iron wire moves over a graduated scale, and the instrument can be calibrated as an alternating current ammeter.

Another instrument depending on the same principle is that of Nalder. In this instrument, which resembles in general construction the ammeter of Elihu Thomson, there is a fixed coil through which the current to be measured passes, and on an axis passing through this bobbin there is fixed a small plate of iron, the field of the binder is made stronger in one part than in others by placing a fixed plate of iron in the opening of the bobbin. When a current is passed through the coil the movable plate of iron is drawn towards the fixed plate, and in so doing turns round the axis to which it is attached. A needle fastened to the axis moves over a divided scale.

A fourth instrument depending on the electromagnetic principle is that of Mr. Evershed, of which I have examples lent me by Messrs. Goolden and Co. In Evershed's alternating current ammeter there is a fixed coil of wire through which an axis passes. This axis carries a small piece of soft iron like a hammer, which is fixed to the axis. Within the coil there are two soft iron cheeks, and between these is formed a strong magnetic field when a current passes through the coils. On passing the current, the movable piece of iron is drawn down between the two fixed cheeks, and this movement is resisted by a weight carried on the axis. The piece of soft iron therefore takes a definite position under any given current which depends on the relative forces acting upon the piece of soft iron. In these electromagnetic instruments it is important to know that in employing them for alternating currents the majority of them have to be calibrated for the particular frequency at which they are to be used. We must not take it for granted, in using an instrument of this class, that its readings will be identical for alternating currents of different frequencies. In the Evershed ammeter, however, a compensation is provided to meet this difficulty, and to make the instruments give identical indications, although the frequency of the alternating current may be varied. The working coil is shunted by an inductive shunt – this shunt takes about 6 per cent. of the total current as direct currents, but only about 2 per cent. as alternate currents. The result is that the working coil takes 2 or 3 per cent. more current with alternate currents, and eliminates any error due to eddy currents set up in the bobbin frame and case.

Before leaving the subject of electromagnetic instruments for the measurement of alternating currents, I may point out one instrument before me which can be employed for the measurement of such small currents as those produced by a telephone. In this instrument there is a fixed coil of wire, and in the centre of this coil is suspended a very small fragment of soft iron wire with its axis inclined at an angle of 45deg. to the plane of the coil. The wire is hung up by a cocoon fibre, and by means of a little fragment of mirror attached to the iron we can detect the smallest movement of the iron. On connecting a telephone to the coil and singing or speaking to it, you see that the iron needle is deflected. The alternating current produced by the telephone passing through the coils of the instrument creates a magnetic field in the interior, and the fragment of soft iron wire tends to turn round so as to place its greatest lengths in the direction of the field of the corner. Hence, the presence of a small alternating current can be detected. By making suitable arrangements and suspending the fragment of wire by a quartz fibre, it is possible to make an instrument sufficiently sensitive to measure the millionth part of an ampere.

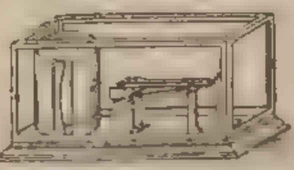

Fig. 10.

I now pass on to consider those instruments for the measurement of alternating currents of strength which depend upon the thermal principle, that is to say, depend for their action upon the heating of a conductor through which the current passes. The first of these which I will describe is the one which is called the twisted-strip ammeter of Profs. Ayrton and Perry. In this instrument a strip of platinoid is stretched between two supports and twisted round in the middle, so that the two halves of the strip form right and left handed spirals. When this is done, and the strip fixed at its two extremities, if an electric current is passed through it, and heats it, the strip tends to twist up more. If an index needle is attached to the centre of the strip, then the passage of a current through the strip may be made to cause this needle to move over a scale, and the position of the needle at any extent to indicate the current going through the strip. If the strip is enclosed in a tube made one third of iron and two thirds of brass, the ends of the strip being attached to the ends of the tube by an insulating support, then no raising or lowering of the temperature of the strip and tube, as a whole, will affect the length of the strip, and hence such an arrangement will constitute a compensation for external temperature. If, however, the strip be supposed to be cooled or heated apart from the tube, it will untwist or twist up more. In order to be able to observe the movements of the strip relatively to the tube, a slit is to be cut in the side of the tube through which the needle attached to the strip can project. In the real instrument the tube containing the strip is fixed on to a stout bracket which divides it into two parts, the compound tube having the same coefficient of expansion as platinoid. A needle attached to the centre of the strip projects through a cut in the tube, and moves over a divided scale. If a current is passed through the strip it heats it, and after a short time the strip assumes a certain definite temperature which is attained when there is a balance between the rate at which the heat is generated in the strip and the rate at which it is radiated to the walls of the enclosing tube. Accordingly there is a definite position of the needle corresponding to any particular mean square value of the strength of the current, and by passing steady currents through the instrument it can be calibrated for use with alternating currents. Such an ampere-meter can be made to read from about ·2 to 5 amperes, reading by hundredths

of an ampere. For the ready measurement of small currents the instrument is convenient, but there are certain difficulties connected with its use which are common to all such thermal instruments.

We may next take note of a very ingenious hot-strip ammeter, invented by Captain Holden, several examples of which, lent by Messrs. Pitkin and Co., are before me. In this instrument there are two metal strips, and (see Fig. 10) of the same length, section, and material. These strips are fastened together by rivets, or otherwise secured at the point E (see Fig.

Fig. 11.

11), and they are also fastened at the other ends to the framework of the instrument. These strips of metal are each of them of a horseshoe shape, and, from proper terminals, a current can be passed through one of these strips. If this is the case, the strip becomes heated, and, if one strip is heated, say the top one, whilst the other one remains practically of the same length, the compound strip will be obliged to assume a new position, as indicated by the dotted lines in Fig. 11. This distortion of the compound strip is made to affect a system of levers which multiplies the motion, and an index arm may thereby be caused to move over a scale, or to move a writing pen over a revolving cylinder. It will be seen that a general rise of temperature of both strips simultaneously, such as would be produced by taking the instrument into a warm place, will not affect the form of the compound strip, since each strip lengthens equally, and therefore there will be no turning movement.

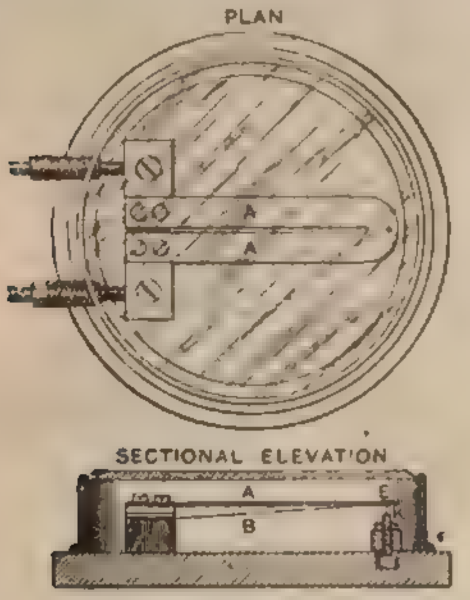

Fig. 12.

In Fig. 12 we have a plan showing the horseshoe shaped strip, the ends of which are attached to insulated blocks of metal, which form the terminals of the instrument. The controlling strip, which is fastened underneath, and is indicated by the letter B, is a plain strip, riveted at one end to A, and the other end to an insulated piece carried on the terminal blocks. Such an arrangement of compound strips may be employed, not only as an alternating current ammeter, but as a means for closing the circuit when a current is increased above a certain amount. A recording ammeter made on this principle, which is an exceedingly simple and effective instrument for recording the strength of large alternating currents, and the rigidity of the strip causes the ammeter to be remarkably dead beat. In the next lecture I shall proceed to describe how these principles are employed in the construction of instruments for the measurement of alternating-current pressure.

LECTURE II.

The Measurement of Alternating-Current Pressure.

Before proceeding to discuss the various types of practical instruments for measuring alternating current pressure, it is necessary to pay attention for one moment to a distinction between electric circuits. I shall have to employ frequently the phrases inductive and non-inductive circuits, and I wish you to be perfectly clear as to the exact meaning of these terms.

Every electric conductor has the property of producing a dissipation of energy when an electric current is passed through it, and it has also the property, as a natural consequence of the above fact, of producing a fall in pressure in the current falling through it. If we consider for one moment a continuous current flowing through a conductor, then if by suitable means we measure the potential at both ends of this conductor, we find there is a fall in potential, or, as it is called, a drop in pressure down the conductor. The number by which we must multiply the strength of the current in amperes to obtain the fall in pressure measured in volts is the numerical measure of the resistance of that conductor measured in ohms. The rate at which energy is being dissipated in that conductor is numerically measured in watts by the product of this resistance and the square of the strength of the current. So far, all is simple when we are dealing with unvarying currents. If, however, we are using alternating currents, then we should not find that the product of the resistance of the circuit and the $\sqrt{\text{mean square}}$ value of the current gave us always the $\sqrt{\text{mean square}}$ value of the drop in volts, neither would it be always true that the product of the resistance of the circuit and the mean square value of the current would give us the mean value of the power taken up in that circuit. In other words, the drop in volts which would actually be observed in the case of an alternating current circuit, especially if it is a circuit wrapped round iron, is more than can be accounted for by the simple resistance of the wire. We find we have in this case to take into account another quality of the circuit, which is called its self induction. In the case of such a circuit the number by which we have to multiply the $\sqrt{\text{mean square}}$ value of the current to obtain the $\sqrt{\text{mean square}}$ value of the E.M.F. is the measure of what is called the impedance of that circuit. We can always measure the resistance of a circuit by means of a Wheatstone's bridge, and if taking any circuit we find that when an alternating current is passed through it the ratio of the $\sqrt{\text{mean square}}$ value of the drop in volts down that circuit to the $\sqrt{\text{mean square}}$ value of the alternating current flowing in that circuit is greater than the true resistance of that circuit, such a circuit is called an inductive circuit, and the above ratio is a numerical measure of its impedance. I can best illustrate this by an example. Two wires, one of platinoid, and the other of manganese steel, were wound into spirals round a wooden frame. Each of these wires was about 25ft. long, and made 40 turns round the frame. In the first place, a continuous current was passed through each wire, and the fall in volts down each wire carefully measured, the magnitude of the current in both wires being ·802 of an ampere. The drop in volts down the platinoid coil was 67·9, and down the manganese coil 79·7 volts. Accordingly the ratio of volts to currents in the first place is 84·66, and in the second case 99·38. This being done, an alternating current of the same $\sqrt{\text{mean square}}$ value, as measured by a Kelvin balance, was passed through the two coils. The fall in volts down the platinoid coil was found to be 68·5, and down the manganese steel coil 80·7. These were the mean square values. The ratio of volts to current in the first case is therefore 85·41, and in the second case 100. These, therefore, are the impedances of these coils, and it is seen that in each case the impedance exceeds the resistance. The frequency of this alternating current was 108, and therefore these coils form slightly inductive circuits. I shall point out presently the manner in which practically non-inductive circuits may be obtained; but meanwhile it is sufficient to remark that if an iron core had been inserted in either of these coils, it would have greatly increased the impedance of that coil. It is always possible, however, to ascertain whether the impedance of a circuit differs from its resistance in numerical value. If it does not to any sensible extent, then the circuit is called a non-inductive circuit. If the impedance is greater than the resistance, then the circuit is called an inductive circuit. There are many cases in which inductive circuits cannot be employed, but in which we must secure, by some means or other, a practically non-inductive circuit. Such a non-inductive circuit can be formed of a series of incandescent lamps, and for larger currents it can most conveniently be obtained by using rods formed of a mixture of plumbago and fireclay, mixed in proper proportions to secure the necessary resistance, and then baked.

Turning now to the question of the measurement of alternating-current pressure, we will consider the various types of instruments which can be used for this purpose. In the first place, any one of the class of electro-dynamometer instruments or electromagnetic instruments described in my last lecture, which can be wound with very fine wire, so as to make a current-measuring instrument of high resistance, can thereby become an instrument for the comparison of alternating current pressure, providing that certain precautions are employed.

In the first place, we may make a high-resistance dynamometer by winding a dynamometer with a wire of high specific resistance and of necessary length. The impedance of this instrument is, therefore, a fixed quantity, provided that we are dealing always with alternate currents of the same frequency. The indications of the instrument are indicative of $\sqrt{\text{mean square}}$ value of the current flowing through it, and hence, by what has been above said as to the definition of impedance, it follows that the $\sqrt{\text{mean square}}$ value of the alternating current pressure at the terminals of the instrument will also be given by the instrumental reading.

In other words, we can take such a high resistance dynamometer and can graduate it for alternating pressure to any given frequency; but if the dynamometer has an impedance which differs sensibly from its true resistance, then, if calibrated for alternating currents of one frequency, it will not, in general, be identical in its indications for alternating currents of different frequency.

We can, however, nearly always secure the condition that the impedance of such an instrument shall differ by very little from its true resistance, and then, when once it has been calibrated, by

testing it with known unvarying pressures, it will enable us to measure alternating-current pressures giving us their $\sqrt{\text{mean square}}$ values.

In order to obtain the necessary non-inductive quality in such an instrument it is generally necessary to place the greater part of the resistance of the instrument in the form of a non-inductive coil of platinoid wire, which is placed outside the instrument, and then to a considerable extent we may be sacrificing sensibility. The same statements are true with regard to the employment of the electromagnetic principle in the construction of alternating current voltmeters. In all the instruments described in my former lecture Siemens's dynamometers, the alternating current ammeters made by Nalder, Evershed, Elihu Thomson, and Dobrowolsky, can be converted into alternating current voltmeters by winding them with very high resistance wires, putting that resistance in the form of a non-inductive resistance associated with the measuring part. In Evershed's current volt-ammeter there is a compensation for frequency which is worth noting. The voltmeter coil has placed in series with it a coil, the terminals of which are shunted by a condenser. This shunted condenser has the property of neutralising the self-induction of the voltmeter coil and if properly adjusted, the instrument may be made to give identical scale indications for alternating pressures of widely different frequencies, and be practically compensated for frequency.

Turning, then, to the instruments for the measurement of alternating E.M.F.'s in which the thermal principle is employed, we have, first, the well-known Cardew voltmeter as a typical instrument for the measurement of such alternating pressures. In this instrument a platinum-silver wire, of about 300 ohms resistance, is stretched in a tube, and, for the sake of compactness, the wire is folded backwards and forwards four times over small ivory pulleys. One end of this wire is fixed, and when a current is sent through the wire it becomes heated, and it attains a final temperature if the current passing through it is constant. The wire, therefore, elongates, and the expansion of the wire is measured and detected by a multiplying gear of the following kind. The elongation of the wire is made to cause a revolution of a mechanism consisting of an intergear of wheels and pinions, and to the last axis of the series an indicating needle is attached, moving over a divided dial. The wire has to be held in a tube or frame, and there are two types of this instrument, called respectively the rod and the tube type. In the rod

FIG. 1.—Holden Voltmeter.

type of instrument, which is the easiest to manufacture, the platinum-silver wire is kept extended by being fastened to two rods, formed one third of iron and two thirds of brass. The whole instrument is then enclosed in a brass case. When the current is passed through the wire it heats it, and the rods become heated also by radiation from the wire. It takes a certain time before the rods settle down into a final state of temperature, in which the heat received by them is equal to the heat radiated by them. Until this is the case, the instrument does not come to its final reading. In the other type of instrument, called the tube instrument, the wire is attached simply to the brass and iron tube, which forms the case of the instrument. In this latter type the outside tube arrives very much more quickly at its final state of temperature, and hence the instruments of the tube type are preferable for accurate work on account of the fact that they thus come much more quickly to their final readings when put upon the circuits. The Edison-Swan Company manufacture a type of Cardew voltmeter which is easier to string than the ordinary tube instrument, and yet has all the advantages of that instrument.

Another disadvantage which the rod instrument possesses is that there is generally a considerable negative variation of the needle, on taking off the current. The rods do not cool as quickly as the wire, and therefore when the current is taken off the needle goes back beyond the zero of the scale. The instruments are generally made for reading pressures from 40 to 150 volts. In the manufacture of the instruments the wire has first to be carefully aged by putting current on and off for some time at intervals of one minute, so as to heat and cool the wire. In this way a certain variation in expansion is got rid of, and the platinum-silver wire is brought into a condition in which it always is the same length and the same temperature. These Cardew voltmeters are really, of course, alternating-current ammeters which take a current of about one third of an ampere at 100 volts. The instrument of this range therefore dissipates a power of 30 watts, and, as I shall point out later on, has the disadvantage of wasting a considerable amount of energy if kept continuously upon the circuit, but when carefully made the Cardew voltmeter is an instrument of great value for measuring alternating current pressure. A special form of this Cardew voltmeter is also made by the Edison-Swan Company for engine room purposes, the dial of which is very large, and which is graduated say, from 80 to 110 volts. In this way such a graduation is given to the instrument that a variation of one volt can be easily seen at a considerable distance. There are some modifications of the Cardew voltmeter which are useful in measuring very small alternating E.M.F.'s, such as the voltmeter of Captain Holden, which you will see amongst the instruments lent by Mr. Pitkin. In this instrument a short and very fine platinum-silver wire is stretched between two supports, and it is kept sagged in the middle by means of a small spring (see Fig. 1). To the centre of the wire is attached a thread, also attached at the other end to the side of a small mirror. If the sag of the wire increases or diminishes, the mirror is more or less pulled round. When a current is passed through the wire it heats it. The sag increases and the mirror is moved. If I apply a very small current to the terminals of the instrument before me, given by a single cell of a battery, you see by the movement of the spot of light upon the screen that the instrument is capable of detecting a very small difference of pressure between its terminals, and, in fact, such an instrument is capable of measuring one hundredth of a volt alternating pressure. This instrument will measure without an external resistance from nothing up to two volts conveniently,

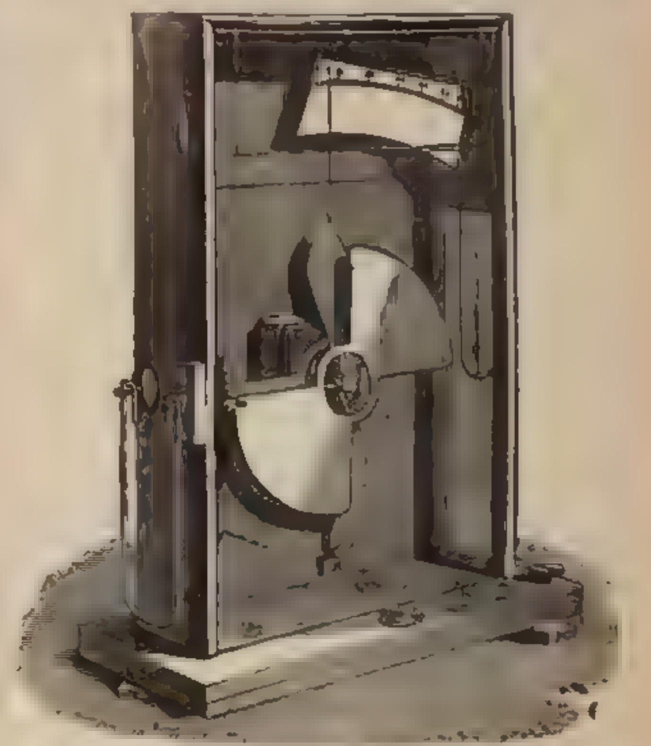

FIG. 2.—Lord Kelvin's Vertical Electrostatic Voltmeter.

and by putting the external resistance in series with it, and by employing a long ray of light, the instrument can be made to indicate pressures of any required voltage with great accuracy. Captain Holden has converted the above described instrument into a useful self-registering voltmeter making a photographic record of variation in pressure. This is achieved by letting the ray of light reflected from the mirror fall upon a revolving drum covered with photographic paper. The drum turns round by clockwork once in 24 hours, and the ray of light marks a photographic record of the revolving paper by which any variation in the pressure is detected and measured. A similar low voltage thermal voltmeter is constructed for use with secondary batteries for measuring the E.M.F. of each cell. In using such thermal voltmeters it is necessary to avoid convection currents of air in the enclosing tube or case. In using a Cardew voltmeter it is generally found best to place the instrument with the tube horizontal. In this way the variable cooling effects of the air currents in the tube are, to some extent, prevented. If a Cardew voltmeter is used with its tube vertical, the needle will be observed to make small movements to and fro, even if the current is perfectly steady. These movements of the needle may, if they occur, prevent the pressure from being accurately read within less than one volt.

We must now pass on to notice instruments for the measurement of alternating pressure which depend upon electrostatic attractions. These electrostatic instruments have for many purposes very great advantages, the most notable of which is that they do not consume power, and that therefore they may be left to the circuits indefinitely without cost. The first of these instruments which I will describe is Lord Kelvin's electrostatic voltmeter for high pressures. In Fig. 2 is shown a sketch of this instrument. You will notice that it consists of four quadrant-shaped plates which are connected to one terminal of the instrument. Suspended between these plates, but insulated from them, is a paddle-shaped

aluminium needle, which swings on very delicate pivots. The needle is connected to the other terminal of the instrument. The instrument in fact, forms a condenser, of which one plate is fixed and the other is movable. When a difference of potential, varying from 1,000 to 5,000 volts, is produced between the

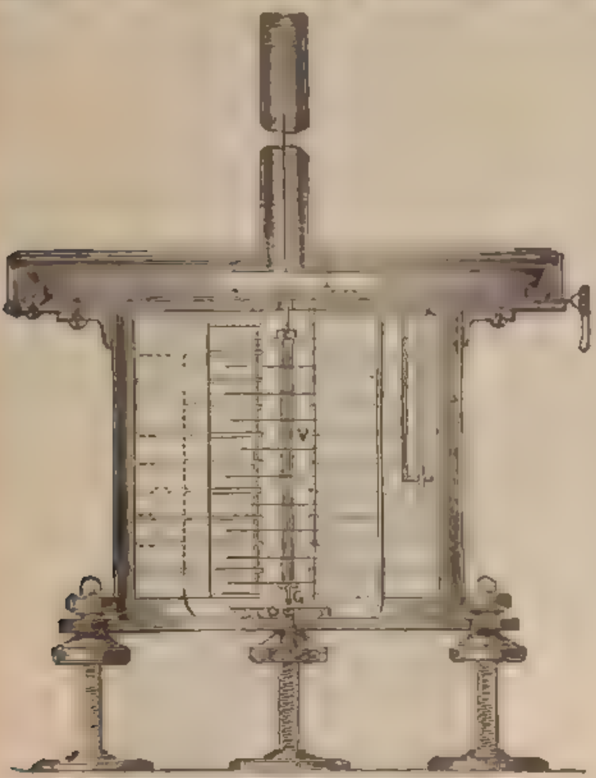

FIG. 3.- Multicellular Electrostatic Voltmeter.

terminals of the instrument, the movable plate is attracted in between the fixed plates. This movement is resisted by weights, which are hung on the bottom of the needle.

When two plates, in fixed positions, have produced between them a difference of potential, the force required to hold them in any given position is proportional to the square of the difference of potential between them. To the end of the aluminium needle is attached a long pointer, moving over a divided scale, and the instrument is graduated in such a manner as to read directly in volts. Since the attraction between the plates depends upon the square of the potential difference, it is independent of sign, and

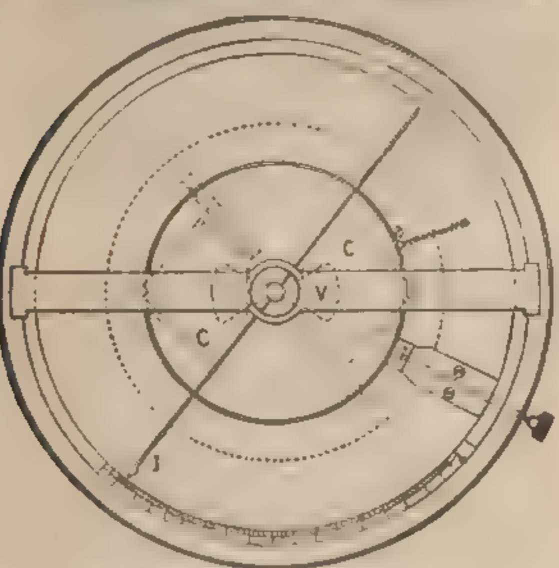

FIG. 4.-Multicellular Electrostatic Voltmeter

therefore the instrument works equally well with direct or alternating pressures; and, in this latter case, it gives us the $\sqrt{\text{mean square}}$ value of the potential difference between the terminals of the instrument.

Another instrument, also invented by Lord Kelvin, but adapted for measuring lower pressures, is the multicellular electrostatic voltmeter. In this instrument there are a series of quadrant shaped plates (see Figs. 3 and 4), placed one above the other, which are called cells. There are then a series of paddle shaped needles, all attached to a common axis, which is hung up by a platinum silver wire. The normal position of the needles is just outside the quadrants, but if a difference of potential is created between the needles and the cells, and the needle is drawn or attracted into the cells, this movement is resisted by the torsion of the suspending wire. An indicating needle, attached to the axis, moves over a divided scale; and the instrument, which can be arranged to measure from 40 volts upwards, gives us, therefore, the $\sqrt{\text{mean square}}$ value of the potential difference between the cells and the needle.

In these instruments there may be a very small error in reading, which is dependent upon the existence of a small E.M.F. of contact between different metals. If the cells are made of brass and the needle of aluminium there is a small contact difference of potential which is due to these different metals, and which may amount to something less than half a volt. Accordingly it will be found that in such an instrument reading, say, 100 volts, the reading given by

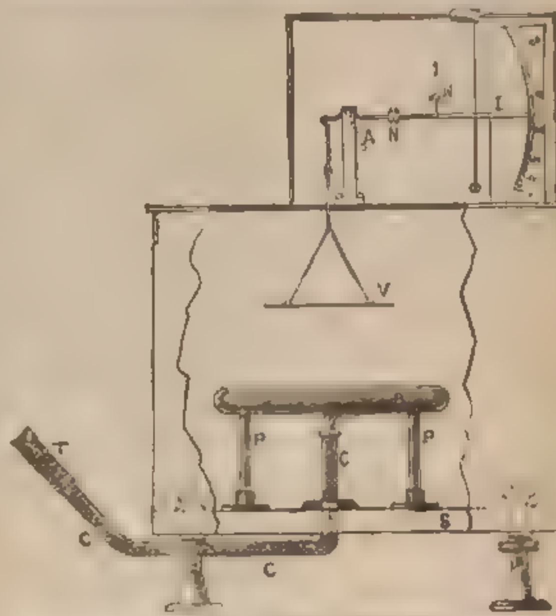

FIG. 5.-Electrostatic Balance.

the instrument will depend upon whether the cells are positive or negative, and a small correction has to be applied depending on the manner in which the instrument has been joined up in calibrating it. Similar instruments for measuring potential differences of much larger amount have been invented by Lord Kelvin. In Fig. 5 is shown the internal arrangements of an instrument intended for measuring from 5 to 40,000 volts. In this instrument the electrostatic attractions between two plates are balanced by the gravity of a weight. One of the plates is a fixed insulated plate, and the other a movable plate hung on a balance arm. The movement of a needle over a scale indicates the pressure in volts. Instruments similar in principle to the above have been devised both by Prof. Ayrton and Mr. Swinburne. In both these instruments the same principle is employed. There is a fixed insulated plate and a movable plate, to which is attached a needle. The electrostatic attractions between these plates are made to move the needle over a divided scale. Lord Kelvin has also devised a form of multi-

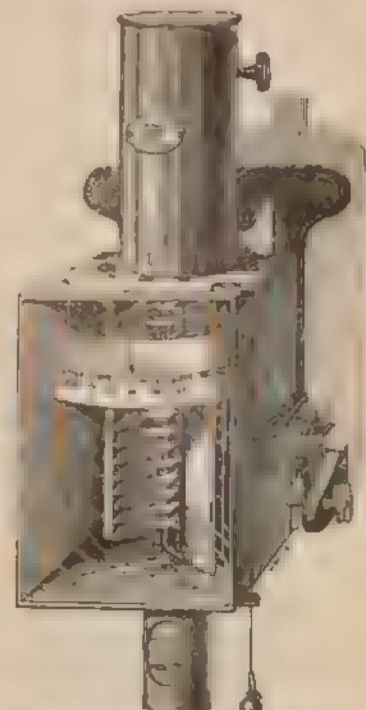

FIG. 6.-Electrostatic Voltmeter for Low-Tension Circuits.

cellular voltmeter, which is useful for central station purposes, as it has a vertical scale, and the instrument (see Fig. 6), is intended to be attached to a switchboard. I may now point out the advantage of these electrostatic instruments to which I referred a moment ago. Take, for instance, a thermal voltmeter absorbing 30 watts, and assume that this instrument is kept connected to the circuits in the dynamo room of a central station all the year round. Since there are, roughly, 8,000 hours in a year, this instrument, absorbing 30 watts, would in one year dissipate 240 Board of Trade units of electric energy. If we reckon this energy as costing 1d. per unit, it is evident that this instrument will cost 240d., or £1, per annum, to keep it going. In reading alternate current pressures higher than 100 volts, a transformer has to be interposed between the circuits and the voltmeter, to reduce the pressure. This transformer will also use up energy, and if it takes no more than the voltmeter it will also waste £1 worth of electric energy in the course of a year. We see, therefore, that an electrostatic instrument which wastes no energy at all is, in cost of upkeep, much superior to the electro-thermal or the electromagnetic type of instrument and, in fact, we can afford to spend a great deal more on an electrostatic instrument, and yet effect a total saving in the cost of the electric measurements in that station. For suppose we capitalise our £1 at 10 per cent., we can then afford to spend £10 more on an instrument of the electrostatic type than one of the electro-thermal or the electromagnetic type, which wastes no more than 30 watts if we keep them on the circuits always. There is, therefore, every reason to believe that in course of time electrostatic instruments for the measurement of pressure will entirely supersede instruments of the electro-thermal or electromagnetic type, in all those cases in which the instruments have to be kept upon the circuits constantly. We may employ these electrostatic voltmeters for the measurement of alternating currents, and convert them into alternating-current ammeters in the following way. Let a non-inductive resistance, say of platinoid wire, be constructed which is capable of passing without sensibly heating the current to be measured, and let the resistance of this wire be accurately known. Then to the ends of this circuit attach an electrostatic voltmeter. Knowing the difference of pressure between the ends of the resistance and its resistance, we know the current flowing through it. In many cases, as in measuring the primary currents of a transformer at no load, it is much more convenient to employ such an electrostatic voltmeter and non-inductive resistance than any other method. Suitable non-inductive resistance can always be made by coils of platinoid wire, joined in parallel; and these must be so adjusted that the final temperature they attain is not more than a few degrees above the normal temperature.

COMPANIES' MEETINGS.

BRUSH ELECTRICAL ENGINEERING COMPANY.

The fourth annual general meeting took place yesterday at the Cannon-street Hotel, E.C., under the presidency of Mr. J. B. Braithwaite, jun. (chairman).

The Secretary (Mr. B. Broadhurst) having read the notice convening the meeting,

The **Chairman**, before moving the adoption of the report and accounts which were published in our last issue, referred to the great loss that the Company had sustained by the death of the Duke of Marlborough, and to the resignation of Mr. E. Garcke (their former managing director), who had transferred his services to the Electric Construction Company, and whose position had been filled by Mr. A. Ayres. Turning to the balance-sheet, they would see that they had issued a certain amount of additional capital. The increase in the Company's business had been so persistent and so steady that they had found it necessary to enlarge the capacity of the Loughborough works, and more accommodation was now required. They had issued £15,000 in new preference shares, and £10,000 additional ordinary shares, for which they were fortunate in obtaining a premium, which, on the other side of the balance-sheet, amounted to £3,551. The debenture stock had been raised to £125,000, which was the total amount authorised. They now owed £37,000 less than last year, and which so far was a satisfactory position. There was an improvement on the balance of trade of £50,000 on the year. On the credit side there was an increase in the item of stock, but that increase represented additional work which they had in hand, and there was nothing in their works except for orders. That item now stood at £91,500, and there was an increase in the work in hand of about £12,000. Cash in hand showed an increase of £2,000, or £3,000 and debentures remained almost at the same figure. With regard to preliminary expenses, they proposed to write off the whole of them out of the year's profits. The liquidators' balance stood very much the same, and the balance of the foreign and colonial was £61,492 instead of £82,737, the greater portion of the difference being due to the sale of the Temesvar station. There had been a slight diminution in the standing charges, and the concentration of the works at Loughborough would lead to considerable economies. They were hardly yet settled down in their new quarters. During the current year they anticipated that the economies which they had effected by concentration at Loughborough would be very apparent, and they hoped to see that figure materially reduced this year. Passing on from other items, the Chairman said if the balance-sheet was sound last year it was very much sounder this year. It was very gratifying that, in spite of the paralysis of business in Australia, their English business alone had resulted in a profit of £50,000. Their shops were full of orders, and the only question was as to whether they could accept orders for delivery within a specified time. Their works in England and Austria were employing 1,300 men constantly, and their orders at home would practically keep them in full work until the shareholders assembled together again next year. It was however, necessary for them to keep their eyes open for new developments, and they had done so in three directions. The first was the completion of the large machines for the City of London Electric Lighting Company. They had undertaken to build for that company 400 kilowatt machines, which were four times larger than they had made. The 200 kilowatt machines last year had turned out well, and those of 400 kilowatts made this year had proved to be even more satisfactory—so satisfactory that the machine had been accepted as a 500 kilowatt machine, and had been paid for extra. Each of those machines could energise 15,000 8 c.p. lamps, and it was very necessary to be able to meet emergencies, because the demand sometimes increased five or six times in less than 20 minutes. The Mordey-Victoria machine was an alternator, and they could also supply continuous-current machines quite as good, if not better, than any other electrical firm in the market. They had, during the year, obtained the sole rights for England for the Desroziers dynamo, and they would shortly place the machines on the market, and he had no doubt that they would do a large business in the Brush-Desroziers dynamo. They had also taken up the manufacture of the Otis elevator, which worked in well with the car building works. He anticipated, in view of the large extension in electric lighting, to supply both motors and lifts. They had made that arrangement in order to have two strings to their bow in their car building shops as in their electrical department. The Company had not been a loser through the failure of the banks in Australia: things were now resuming their normal course, and they were beginning to receive remittances. In Austria their profits had suffered owing to the competition in the lamp trade, and they had now made that branch of a secondary nature, and had made arrangements to do installation work and to construct dynamos. After referring to the development of traction in the United States, the Chairman said that there now seemed to be some progress being made in this direction in this country. He said that electric traction would become an important part of their business at no distant date, and they had exceptional facilities for dealing with that kind of work, because they could not only build engines and motors, but they were also able to entirely complete orders themselves at their Falcon Car Works. When traction began to occupy a prominent place in this country, the Brush Company would be found to have a fair share of the work. Dealing with municipal electric lighting, he said that the Company had done well in the supply of plant. They had just started the Huddersfield station, and they had at present work in hand for Bolton, Leicester, Lancaster, Worcester, etc. They had an order for the supply of continuous-current machines, and they had done a considerable amount of work for private companies, as, for instance, at Coatbridge, Bournemouth, etc., and were doing other work for Canterbury and elsewhere. He referred to electric lighting in the metropolis in detail, and then spoke of the forthcoming expiration of the Edison master incandescent lamp patent. The Company looked forward to that because they believed it would assist materially in inducing people to adopt the electric light. They would soon resume the manufacture and sale of their incandescent lamps, and then they would be able to supply their customers with everything. He then moved the adoption of the report and accounts.

The motion was seconded by **Mr. B. H. Van Tromp**, and was adopted.

The **Chairman** then moved the payment of the dividends recommended. This was seconded by **Colonel F. G. Stouart**, and was carried.

The election of Mr. A. Ayres was confirmed. Messrs. Braithwaite and Van Tromp were re-elected directors, and the auditors, Messrs. Cooper Bros., were reappointed.

The proceedings terminated by votes of thanks to the Chairman and other Directors, and to the engineering staff.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY.

The ordinary general meeting was held on Wednesday at the City Terminus Hotel. Mr. William Addison presided. In moving the adoption of the report, the **Chairman** congratulated them on the steady increase of their business, although the depreciation in the value of silver had prevented their showing any great improvement in the net results of the year's working as compared with the previous year. The appeal to the House of Lords had been allowed, and consequently there was a sum of about £13,000 owing by the holders of vendors' shares on account of interest payable to the holders of ordinary shares during the first five years of the Company's existence. He was glad to inform them that, after many representations to the Government of India in regard to the competition of the Indian Telegraph Department through that Department installing and undertaking to supply telephonic communication in districts for which they had granted licenses to the Company, the Government had seen fit to withdraw from the competition in these specially reserved districts. It certainly did seem unreasonable that the Telegraph Department should compete with this Company and its subsidiary companies, and at the same time extract royalties from the Company. Including the amount (£1,957) brought forward

there was a sum of £11,043 to be dealt with. The Directors proposed to add a further sum of £2,500 to the reserve fund, bringing it up to £12,500, all of which was invested in consols. The dividend now recommended was equal to £3 12s. per cent. on the ordinary shares. **Mr. Henry Grewing** seconded the motion, which was unanimously adopted.

BUSINESS NOTES.

St. Pancras. - We understand that Messrs. Johnson and Phillips have obtained a contract for these extensions.

Toxteth. —As will be seen by our advertisement columns, the Local Board require an inspector for electrical purposes.

Telegraph Insulators. —The strikers in South Wales, having nothing better to do, have been breaking telegraph insulators instead of coal.

Cleckheaton. —The Cleckheaton Local Board have decided to invite tenders for the fixing of electric alarm bells in the houses of all the members of the fire brigade.

Personal. —Mr. A. E. Pullen, of Bournemouth, has been appointed assistant electrical engineer to the Huddersfield Town Council at a salary of £130 per annum.

Watford. —Replying to Mr. Clifford at a meeting of the Town Council, the clerk stated that the matter of obtaining a provisional order for lighting the town by electricity was going forward.

Bury. -The Electric Lighting Committee of the county borough of Bury invite applications, as will be seen from our advertisement columns, for the appointment of a resident electrical engineer.

Barton. —The Workhouse Extension Committee have been instructed to enquire and report whether it would be more economical to light the new workhouse hospital at Patricroft with the electric light than with gas.

Babcock and Wilcox. —The directors of Babcock and Wilcox, Limited recommend dividends for the half year ended June 30 last at the rate of 6 per cent on the preference and of 10 per cent. per annum on the ordinary shares.

West African Telegraph Company. -The half-yearly interest, due on September 1 next, will be paid on and after that date by the National Bank of Scotland, 37, Nicholas lane, E.C. Coupons must be left three clear days for examination.

Telephony. —The National Telephone Company have arranged to keep their exchanges at Plymouth, Exeter, Torquay, and Paignton open day and night, including Sundays and holidays, and the trunk wires between those places will always be available.

City and South London Railway Company. —The receipts for the week ending August 20 were £860, against £724 for the same period last year, or an increase of £136. The total receipts for the second half year of 1893 show an increase of £526 over those for the corresponding period of 1892

Waterhouse Electrometric Syndicate, Limited. —This Company has been registered with a capital of £20,000 in £10 shares. The object is to adopt an agreement made between A. G. Waterhouse and A. T. Salisbury Jones of the one part and this Company of the other part, for the acquisition of certain patents, patent rights, etc.

Folkestone. —At a meeting of the General Purposes Committee of the Town Council on the 13th inst., Councillor Thompson asked the Mayor when he would be able to give them a day for the Electric Light Committee meeting. The Mayor said that he could not fix a day just that moment. He thought it would be within a week.

Bradford. —A tentative report has been presented to the Town Council by Mr. John Waugh, C.E., with respect to the type of engine to be used in the extensions of the central station. The Lighting Committee has resolved to extend the works and mains at a cost of rather more than £4,000, including the purchase of two engines and the switchboards.

Personal. -We are informed by Mr. W. H. Watkinson, of the Central Science School, Sheffield, that he has been appointed to a professorship at Glasgow. Mr R. Hammond informs us that he has decided in future to confine himself to consulting engineering, and that when the contracts to which he is at present committed are completed, he will only do consulting work.

Whitehaven. —The work of fitting the public lamps is progressing satisfactorily One or two local firms who are undertaking to fit up the electric light for private firms have received numerous orders, and have been kept busy for the past few weeks. It is expected that the public lamps will be lighted this week, and that the private supply will be available on September 1.

Blackpool. —The electric tramway on the promenade, and which was taken over by the Corporation on 9th September, 1892, cost the Town Council £28,964 Between that date and the 25th March this year, the expenses were £2,964 and the receipts £2,361, leaving a deficiency of £603. It is in the season, however, that the profit is made, and the accounts from March to September should present a much better appearance.

Telephony at Glasgow. —The Postmaster General, in acknowledging the receipt of the application by the Corporation of Glasgow for a telephone license, states that the matter is receiving his consideration. A communication on the same subject has been forwarded to the Postmaster General by the Association of Municipalities, who request to be heard before the postal authorities come to any agreement with the National Telephone Company.

Burton. —Through an oversight in our last issue it was stated that the Gas and Electric Light Committee of the Bolton Town Council had recommended the acceptance of the tender of Messrs. John Fowler and Co (Leeds), Limited, for providing an overhead crane, and that of Messrs. Bryan, Donkin, and Co. for fitting boilers and furnaces in connection with the electric light works. The name of the town should have been Burton, and not Bolton.

Micanite Insulation. -We are informed that Messrs. Bergtheil and Young, of 13, Walbrook, E.C., have been appointed sole European agents of the Mica Insulator Company, of New York, for the sale of micanite insulation. By its use it is claimed that the full benefit of the insulating properties of pure mica is obtained, together with the advantage that micanite is obtainable in large sheets up to 36in. by 36in., or even larger if required, and of almost any desired shape.

G. E. Belliss and Co., Limited. —This Company has been registered with a capital of £150,000 in 10,000 ordinary and 5,000 6 per cent. cumulative preference shares of £10 each. The object is to acquire the business of engineers and boilermakers now carried on by G. E. Bellias and A. Morcom, under the style of G. E. Bellias and Co., at Ledsam street Works, Birmingham, and to carry on the business of mechanical, electrical, and general engineers, boilermakers, etc.

Kelso. —The electric light installation at Newton Don, Kelso, for Mr. Charles B. Balfour, is now completed. Power is supplied by a turbine at the Lyna waterfall, which drives a dynamo from which the current is conveyed to the mansion by an underground cable some 500 yards in length. Altogether there are some 300 incandescent electric lamps. In addition to its use for lighting, electricity is also employed for boiling water, heating irons, and for other domestic purposes. The installation has been arranged and carried out by Messrs. A. A. C. Swinton and Co., of Westminster.

Direct Spanish Telegraph Company. —The report of the Direct Spanish Telegraph Company for the half-year ended June 30, states that, after providing for debenture interest, a balance remains of £4,646. After adding £2,500 to the reserve fund, the balance of profit and loss amounts to £2,146. To this the Directors propose to add £345 from the interest on investments, and recommend a dividend at the rate of 10 per cent. per annum on the preference, and at the rate of 4 per cent. per annum tax free on the ordinary shares. The reserve fund will then amount to £35,963.

Edmonton. -At a meeting of the Board of Guardians on the 16th inst., the Chairman suggested that while extensive alterations were now being carried out at the Edmonton Workhouse, it would be a suitable time for ascertaining what would be the cost of lighting the premises by electricity. It might be found that electric lighting would be more economical than gas lighting, and that there would be sufficient power for the purpose already in their engine room, or that it could be increased at very little cost now that other works were in progress. The matter was referred to the Works Committee.

Derry. —The municipal generating station is nearly completed by the contractor, Mr. Matthew M'Clelland, and Messrs. Alexander Brown and Sons are proceeding to place two boilers in position. A staff of men are engaged erecting the street lamp-pillars. The engines and machinery for which this firm have tendered are in a forward state, and will be erected as soon as the engine foundations are laid. Messrs. Siemens Bros. and Co., Limited, have two of the dynamos, and also the switchboard, ready for delivery, and the remaining dynamos are nearly completed. It is expected that this firm will proceed immediately to lay the street mains. The arc lamps will be fixed on the pillars as soon as these are placed in position. On the whole, the lighting scheme is in a fair way to be fully installed about the month of October, so that the city will be lighted during the coming winter. Various firms are prepared to light their works from the Corporation station.

Weybridge. —At a meeting last week of the Chertsey Union Rural Sanitary Authority, a letter was read from Mr. H. C. Buchanan, the secretary of the Weybridge Electric Supply Company. Mr. Buchanan wrote that Mr. Kite had forwarded him the Authority's letter drawing attention to Section 2 of the Weybridge Electric Supply Order, 1891, as confirmed by 54 and 55 Vic., cap. 105, limiting the time for removing the existing overhead wires. He had duly submitted the same to his directors, and, in reply, was directed to inform them that Prof. A B. W. Kennedy, F.R.S., had been retained on behalf of the company to advise as to the proper course to be pursued in reference to placing the electric lines underground. Unfortunately Prof Kennedy would be absent from London for some weeks, and therefore unable to give attention to this matter until his return. Mr. Buchanan, however, assured them that no time would be lost in removing the overhead wires complained of.

Scarborough. — The minutes of the Electric Lighting Sub-Committee adopted at a meeting of the Town Council last week were as follows: "The town clerk submitted draft deed of transfer from the Corporation to the Scarborough Electric Supply Company, Limited, as altered by the Board of Trade, together with their explanations how the alterations therein have been made. Resolved That the draft as altered be approved, except that portion of Clause 1 which provides that if any electric inspector be appointed his fees be paid by the local authority, and that the town clerk be instructed to inform the Board of Trade that the committee consider that if any electric inspector should be appointed, his fees should be borne by the company. Read: Letter from the resident engineer of the Scarborough Electric

Supply Company, Limited, enclosing tracing of proposed deviation from the original plan of mains in Filey-road. Resolved: That such proposed deviation be approved."

Bradford.—The chairman of the Gas and Electricity Committee of the Bradford Corporation (Alderman Frederick Priestman) has announced his intention of resigning that position in November next. He mentioned last week that they had had to refuse a large number of applications, and he believed that if they had double the quantity of electricity to sell customers would quickly be forthcoming for it. The committee had held back because they thought it desirable to ascertain whether they could improve their system, and they had consulted Lord Kelvin, who had recommended the three wire system. Lord Kelvin had also said that if the Corporation had to begin again to-day they could not adopt a better plan than they did five years ago. He hoped the committee would be able to get one of the engines which they proposed to order running before the winter set in, otherwise they must face the winter with some apprehension, because the work put on the engines and plant last year was more than it was safe for them to carry. They had not any spare power if one of their engines had broken down.

Bristol.—At a recent meeting of the Board of Guardians, the question of electric lighting at St. Peter's Hospital was referred to the Court of Assistants, who reported last week that they had considered the communication from the Electrical Committee of the Bristol Town Council, and that they found that the only expense the Guardians were asked to pay was in respect of about 80ft. of the "lead in" mains down the church path, costing about £9, the remainder of the expense of extending the mains to the front gate and 30ft. down the path being borne by the Council. The committee, therefore, unanimously recommended the Guardians to pay for the extra length of "lead in" mains at the estimated cost of £9, and to receive and pay, for a period of two years for electric light, not less than £4. 16s per annum. With regard to the supply and fixing of the necessary lamps, decided on by the Guardians on the recommendation of the committee on April 21, and then estimated to cost about £30, the committee thought it would be desirable that tenders should be now obtained, and asked for permission to take such action as they might think fit to obtain a specification and tender for the consideration of the Guardians. The report was adopted.

Harrogate.—In our last issue reference was made to the postponement of the decision of the Corporation in regard to the establishment of a municipal station. A decision has, however, now been arrived at. On Monday a meeting of the Corporation was held to consider the question. The question has been an open one for the past two years, the Council having taken up the Board of Trade powers to light the town with electricity. The time having expired, the General Purposes Committee decided to advertise for tenders from companies willing to supply electricity, and that, if so advised, the Board of Trade be communicated with with a view to the modification of the compulsory area of supply. At a further meeting of the General Purposes Committee, as mentioned last week, it was resolved to recommend that the Council should carry out the electric lighting order, and that Mr. Wilkinson, consulting engineer, should be instructed to work out the details of a scheme on the basis of the report presented to the committee, and that as soon as the scheme had been sanctioned by the Board of Trade, application be made for a loan for the establishment of the installation within the borough. The Mayor (Alderman Simpson) presided, and Mr. J. H. Wilson advocated the adoption of the electric lighting scheme by the Corporation. The resolution for the Corporation to undertake the lighting of the town was, after some discussion, carried by thirteen votes to seven.

Electric Lighting of Bolton.—Major General Crozier, one of the inspectors of the Local Government Board, conducted an enquiry on Tuesday at Bolton into the application of the Corporation to secure power to borrow £40,000 for electric lighting works, and £5,000 for works of sewerage. There was no opposition. The Town Clerk said the Corporation were empowered to supply electricity within the borough, the authorised area of supply being the whole of the municipal borough. A sub committee of the Corporation was appointed in 1891, which determined upon the alternating current high-tension system. The generating station would be placed at Spa Field. At present they did not contemplate street electric lighting. The necessary building and laying of plant were intended to be commenced forthwith, and tenders for almost the whole of the work had been obtained. The outlay at present involved would amount to about £21,000, but they had to consider and provide for the eventuality of being called upon to supply beyond the compulsory area. A point was suggested by the inspector as to the sum involved in the application over and above the amount actually to be expended at present. The Town Clerk stated, in reply, that they were liable at any time to be called upon to supply beyond the compulsory area. The Inspector suggested that £30,000 might be sufficient, and it was stated that this amount would permit of another engine and dynamos being laid down. This point was, however, left for the consideration of the Local Government Board.

Windsor and Eton.—The Windsor and Eton Electric Lighting Company stopped the supply last Saturday week, and has gone into liquidation. This company has had a somewhat chequered career, and can never have been in a strong position, or received general support in the district it was intended to serve. The *Windsor and Eton Gazette*, in a leader on the subject, says: "The stagnation—indeed, we may now say the stoppage—in the supply of electric light to the towns of Windsor and Eton is a scandal and disgrace to the community. The statement may be emphatic, but it is absolutely true—albeit, undirected against any individual or corporation. At a time when almost every town of importance has adopted the electric light, and when there are hundreds in Windsor wishing to avail themselves of the clean and wholesome illuminant, it is monstrous that either misfortune or mismanagement should debar all progress towards improved public and private lighting. The deadlock, which must be disastrous to those who have invested in the more or less moribund electric lighting company, cannot be ultimately beneficial to those who are interested in the supply of gas; and, so far as concerns the general interests of the two towns, it must, the longer it continues, prove increasingly disastrous. With the manner in which the existing conditions of things has been brought about we are not immediately concerned, nor, indeed, do we care too closely to enquire; but against the continuance of the present mockery to modern civilisation we do protest, and for the commencement of a brighter era of prosperity we enter our most earnest and solemn plea."

Lighting at Leicester.—On the 17th inst., Major General H. Crozier, R.E., Local Government Board inspector, held an enquiry at Leicester concerning the application of the Town Council to borrow £50,000 for the purpose of electric lighting. The town clerk appeared for the Corporation, and Mr. D. Wright said he opposed on behalf of the Ratepayers' Association. Mr. Storey said that the Corporation had determined to proceed themselves upon a provisional order, and this was granted in 1890. Since that time the Gas Committee had been pursuing enquiries in England and on the Continent, and the Council had accepted a scheme sent in by the Brush Company, whose tender amounted to £26,977, and whose plan had been recommended by Prof. Kennedy. The Board of Trade had also accepted it. The buildings would cost £4,000, and contingencies would raise the amount to £34,074, besides which the Council sought to take borrowing powers for £15,926 for future extension of mains, which was a moderate thing to do. The Corporation desired to have the electric light in their own hands, and not allow a private company to come in, who might have to be bought out in the course of a few years, especially as they already possessed the gasworks, in whose premises the electric lighting works could be built. Alderman Lennard said the Corporation already had applications for 4,000 lights, and the plant would supply 7,200 lights of 16 c.p. The price to be charged would depend upon the demand. The Corporation were going to work the scheme as a commercial undertaking. Mr. Wright opposed the application, urging that the matter should be delayed for five years in view of the heavy rates with which the town was burdened. The Inspector pointed out that unless the Corporation acted at once the Board of Trade might allow a private company to step in, which would then obtain a monopoly, and if the Council desired to obtain possession of the work they would have to buy them out as in the case of the gas and water works. The Ratepayers' Association could not expect to have the same weight as a Corporation representing the town.

Aberdeen.—The subject of the powers of the National Telephone Company was discussed at a meeting of the Town Council on the 21st inst. Mr. Bisset moved "That the Town Council petition the Postmaster General to lay on the table of the House of Commons, unsigned, the terms of agreement at present being negotiated by him with the National Telephone Company." He said this matter had now got into a very critical position so far as municipalities were concerned, and the Association of English Municipalities and several of the larger towns, both in England and Scotland, had already entered into communication with the Postmaster General on the subject. An understanding had got abroad—whether it was well founded, of course, they were unable to say—that the Postmaster General had entered into an agreement with the Telephone Company conveying to them all the powers which he possessed under the Telegraph Act and subsequent Treasury minute, and if that understanding was correct, the National Telephone Company would have got what would practically mean statutory powers to enter upon property and take lands for the purposes of their undertaking. He thought that every town council would at once admit that it would be a very serious thing if any company were to be allowed to enter upon the streets of a city for the purpose of putting down underground cables for telephonic communication; and that was what was contemplated, because a committee of the House of Lords and the House of Commons which had had the question under consideration, had condemned the system of overhead wires, and had recommended that the undertakers of telephonic communication should get powers to put the cables underground. If that were to be done they must very carefully watch the nature of the powers to be granted, and he thought it would be well for the Town Council to protect themselves by insisting that the terms of the agreement should be made public, so that everybody might know what they really were. He would also suggest that the town clerk be asked to write the local members of Parliament to use their influence in getting the agreement made public before the Post Office Department agreed to it. If that did no good, it could certainly do no harm. The fact that other bodies were taking up the matter was *primâ facie* evidence that there was some reason for Aberdeen moving in it. The matter was referred to the Finance Committee.

Worcester.—At the quarterly meeting of the Town Council on the 15th inst., the Mayor moved a resolution, "That the Council adhere to the proposal that the generating station shall be constructed at Powick Mills; that the Council accept the tender of Mr. Thomas Rowbotham, of Coventry road, Birmingham, for the erection of the electric lighting generating station at Powick Mills, in accordance with the plans and specifications prepared by

the surveyor, and with brick structure, for £14,797, subject to Mr T. Rowbotham entering into a contract for the work containing such provisions as the town clerk may think necessary, and also to order that the common seal be affixed to the contract." The Mayor said it would be recollected that at the last meeting a motion was brought forward to ask Mr E. D. Marten to report on the cost of making the Teme navigable up to Powick. The resolution was withdrawn on the understanding that the matter would be reintroduced at that meeting, when there would also be a report on the comparative cost of erecting a generating station at Powick, and erecting a station in the city. The committee had had reports from the city surveyor and from Mr W. H. Preece, upon whom they had looked, and hoped to look as their consulting engineer. The reports set out in a simple and complete manner the advantages of a station at Powick Mills over a smaller station erected in the city. Whatever doubts they might have had as to the wisdom of obtaining electric energy from water power had altogether been cast aside by the fact that in spite of the long and protracted drought there had been no day when less than 300 h.p. would have been available at Powick. Such a large horse-power would enable them to produce electrical energy at one-fifth of a penny per unit. Knowing the liability of estimates to be under the mark, he would take it at ½d., even ¾d. per unit. It might seem a large sum to put up a small station; but when they had such power running to waste which could be usefully employed in various developments likely to take place, it would occur to them to look 5, 10, or 15 years ahead, and forestall the future. The difference between £26,000 and £40,000 was not to be lightly despised, and it was quite possible that the £40,000 would amount to nearer £50,000. When he told them that by going to Powick they would produce their energy at one-sixth of the cost at a steam station, that was a sufficient reason to go outside. It might be asked, why go to such expense when the lights to be taken were so problematical? He admitted that unless the Corporation and the citizens were going to do the best they could for the city, then, by all means, let them not go to Powick. But the Corporation ought to support what the majority considered for the welfare of the citizens and the city. If they were to be met by what ought to be city interests going in an opposite direction to that the Council wished—he need not mention the particular case he had in mind—and if the Council were not going to use the electrical energy at so small a cost for motive power with regard to pumping machinery for water and sewage works he was afraid that any scheme of that magnitude—even though they could produce at so small a figure as ¾d. per unit—would be no use whatever. They would have to pay for the land in any case. They had committed themselves to an expenditure of £5,000, so that the approximate cost of the lesser scheme would be £31,000, because of the unproductive initial expenditure of £5,000. Unless the opinions of the experts consulted were altogether wrong, they should abide by their original determination, supported as it was unanimously by the Watch Committee. If they went to Powick, before very long they would have to light their streets by electricity. Their gas bill now amounted to £3,200 per annum, and that money would more than repay annually the amount they would have to disburse in the repayment of the principal and interest on the £50,000. There would be certain necessary expense in first substituting electric light for gas, but the benefits likely to accrue and the certain economy were sufficient argument for electricity. If they did not light the city by electricity, they would deprive them at once of an enormous revenue. In passing, he remarked that after a 12 months' trial the city of London were perfectly satisfied with the electric light, which was being worked by the same company as would do the work in Worcester. He thought members ought to have no fears as to the success of the enterprise, which, he ventured to hope the Council would see their way to sanction. Alderman Hill seconded, thinking the Council by that time thoroughly understood the subject. Mr Millington said he was not opposed to electric lighting. He was strongly in favour of it, and would support having it at almost any cost. He moved the amendment simply because he thought that the end might be attained by cheaper means. To adopt the Powick scheme would be to tax the ratepayers heavily; and by beginning in a small way they could take advantage of future improvements. He moved as an amendment that the Powick site be abandoned, and that the committee be instructed to put down plant with a steam generating station in the city of Worcester, at a total cost not exceeding £20,000. Further discussion then took place, and on the amendment being put, it was lost by 22 votes to 10, and the original motion was carried with five dissentients. The Mayor moved that Mr W. H. Preece be retained as engineer at a commission of 2½ per cent. Alderman Ernest Day seconded, considering that by appointing Mr Preece they would be certain the work would be carried out efficiently and well. The motion was adopted.

PROVISIONAL PATENTS, 1893.

AUGUST 14.

15409. **Improvements in electric switches.** Benjamin Greenwood Smith, Penny Bank chambers, Halifax.

AUGUST 15.

15476. **Improvements in primary voltaic batteries.** Luis Falero, 100, Fellows road, London.

15485. **Improvements in glow lamps and holders.** Edward Mann and James Hopwood, 77, Chancery-lane, London.

15479. **Improvements in electric arc lamps.** Louis Emerson Howard, 115, Cannon street, London. (Complete specification.)

15486. **An automatic switch for electric and other light, applicable to a door.** Edward Mann and James Hopwood, 77, Chancery lane, London.

15510. **Improvements in electric arc lamps.** James Brockie, 28, Southampton buildings, Chancery lane, London.

15519. **Improvements in electric engines.** Reginald Walter Barker, Monument chambers, King William street, London. (The Lawrence Electric Company, United States.) (Complete specification.)

15523. **Improvements in recording meters for electric light and power circuits.** William McNeill, James Henry Tinder, and Smith Peter Kerr, 53, Chancery lane, London.

AUGUST 16.

15577. **Improvements in electric furnaces.** Frédéric Chaplet, 46, Lincoln's inn fields, London.

AUGUST 17.

15610. **Improvements in apparatus for the electrolytical decomposition of brine and other liquids.** Francis Gibson Baily and Malcolm Guthrie, 46, Lincoln's inn-fields, London.

15617. **Improvements in apparatus for the electrolytical decomposition of brine and other liquids.** Francis Gibson Baily and Malcolm Guthrie, 46, Lincoln's inn fields, London.

AUGUST 18.

15663. **Improvements in the covers and frames of manholes, used for drainage work, electric light, and other purposes.** Frederick Charles Lynde, 25, Cross street, Manchester.

15669. **Apparatus for the electrolytic treatment of liquids.** Newnham Browne, 73, Cheapside, London. (Alfred Vogelsang, Germany.) (Complete specification.)

15681. **Improvements in electric accumulators or storage batteries.** George Henry Roe and Gustav Sutro, 52, Chancery lane, London. (Complete specification.)

15690. **Improvements in electric marine governors.** David Tweddle, 46, Lincoln's inn-fields, London.

15715. **Improvements in or connected with means for the supply or distribution of electricity.** William Godson Little and Charles William Godson Little, 47, Lincoln's inn-fields, London.

AUGUST 19.

15736. **Improvements in and relating to machinery for covering telegraph, telephone, and electric cables, and wires with lead or metallic compounds, also applicable for the manufacture of metallic pipes and the like.** George Edward and Thomas Edward, 70, Wellington street, Glasgow.

15776. **An improved electric apparatus termed "guberno graph" for use on ships to indicate and register the position of the rudder and the reversing gear of the engine.** Joseph Leopold Huber, 45, Southampton-buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED

1892.

17160. **Telephone switchboard apparatus.** Kingsbury. (Western Electric Company.)

17246. **Electric batteries.** Rawlins.

1893.

519. **Electric resistance boxes.** Lake. (Weston.)

9358. **Electric lighting, etc.** Binswanger.

11099. **Electric glow lamps.** Lake. (Colby.)

11680. **Electric alarm apparatus.** Sauer and Hentzschel.

12457. **Electric conductors.** Urquhart and Small.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid	Price Wednesday
Brush Co.		3¼
— Pref.	—	2¼
City of London	—	11
— Pref.	—	12¾
Electric Construction	—	—
Gatti's	—	5¼
House to House	5	5½
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	6
National Telephone	5	4¾
St. James, Pref.	—	8
Swan United	3½	3¼
Westminster Electric	—	5½

NOTES.

Quintin.—Extensions are to be made in the electric lighting plant.

South Africa.—A telegraph line is being erected between Campbell and Griquatown.

Gibraltar.—The colonial report for Gibraltar states that the Electric Light Loans Ordinance was passed last year.

Dortmund.—The electric tramway now being constructed is expected to be set in operation by the end of the year.

Manchester.—Questions are being asked as to when the supply of light to the public will be available from the municipal station.

Kingston-on-Thames.—The Town Council expect to be in a position to supply current in October, the charge being 6d. per unit.

Mining Engineers.—The annual meeting of the Federated Institution of Mining Engineers will be held in Glasgow next week.

Mans.—The Mans Chamber of Commerce has decided to establish an urban telephone system and a circuit between Paris and Mans.

A Large Corona.—The main building of the Imperial Diet has been equipped with a large corona containing 12 arc lamps and 250 incandescent lamps.

Finland.—It is proposed to establish a State telephone system, and as a commencement the work of connecting the towns of Abo and Viborg has already been begun.

Telegraphy.—An enterprising individual a few days ago, at a Liverpool telegraph office, used no less than 146 forms in trying to word a message within the prescribed value of 6d.

Exhibition at Madrid.—A Universal Exhibition is to be held at Madrid from April 1 to October 31, 1894. The prospectus may be obtained at the Spanish Consulate, 23, Billiter-street, E.C.

Lighthouse Illumination.—The Commissioners of Irish Lights are seeking statutory sanction of the Board of Trade for the installation of the electric light as a fixed light at the Old Head of Kinsale.

Museum-Lighting.—The working expenses, including repairs, of the electric light plant at the South Kensington Museum reached £1,267 last year, and at the Bethnal Green Museum they amounted to £528.

Traction.—Electric traction people should look after the Dudley and Wolverhampton Tramways, Limited, which has been formed to acquire the undertaking of the Midland Tramways Company, and construct tramways in the county of Warwick.

Lighting of Spinning Mills.—The various buildings belonging to the firm of Petrikowsky and Co., at Schwedewitz, near Zwickau, are lighted electrically, and the spinning machinery is operated by electric motors. The power is supplied partly by steam-engines and partly by turbines.

Overhead Circuits.—The work of abolishing overhead poles and wires in New York City is still going on. It is stated that during the month of July the electric light companies removed a large number that had been condemned, to the extent of 24 poles and no less than 233 miles of wire, without expense to the city.

Live and Learn.—Mr. Edison has been engaged in seeing the wonders of the World's Fair. He has, of course, been asked his opinion of the exposition, and has said: "No man who has to make a living by his intellect can afford to stay away from it. I put it on a business basis. I find new ideas of motion and many other things in everything I see. It is all a study for me."

Llandudno.—A scheme is proposed for establishing a *funiculaire*, or cable tramway, to one of the highest points on the Great Orme's Head. Dr. Nicol, chairman of the Pier Company and the Marine-drive enterprise, is taking a warm interest in the matter, and it is said that the whole of the money is ready for undertaking the work. Here is probably an opportunity for the line to be operated electrically.

Low Water.—The Neversink Mountain railroad and one other electric car line at Reading, Pennsylvania, have been obliged to stop running for a time on account of the drought, their power being derived from a waterwheel in a river which is also used to feed a canal. One would think it a pity that, in view of some such possible occurrence, a small steam plant was not erected as a stand-by in case of emergency.

Military Telegraphy.—The cables which in military ports form connections between the works of defence and the network of submarine conductors terminating at torpedoes and at alarms are frequently within the reach of passers by in France. The importance of maintaining regular working in time of war has induced the French Minister of Marine to take steps to ensure proper supervision of these lines.

Bristol Industrial Exhibition.—The main building in which the Industrial and Fine Arts Exhibition is being held this week is lighted by 20 arc lamps of 1,000 c.p. and about 400 incandescent lamps of 16 c.p. Eighteen arc lights illuminate the industrial section. The arts section is lighted entirely with incandescent lamps, electroliers of numerous designs being brought into requisition. The current is obtained from the Corporation works. A searchlight has been placed on one of the towers.

The Junior Engineering Society.—The annual summer excursion of this society, which has just taken place, passed off in a very successful manner, the whole programme affording the greatest gratification to the members attending. The district visited was Wilts., Devon, and Cornwall. From the appreciative remarks of the members, it does not seem likely that the generous reception accorded the society on this its first visit to the West Country will be readily forgotten.

The Hughes Recorder.—The Post Office authorities are reported to be experimenting between London and Liverpool with a view to introducing the Hughes recorder as a substitute for the Morse instrument in the sending of newspaper messages. The Morse instrument is excellent for newspaper work, for it permits of as much as 400 words being sent per minute. The advantage of the Hughes instrument is that the message is typed, whereas the Morse message is flimsied for newspapers.

New York Electrical Work.—The report of the Department of Public Works in New York City for the quarter ending June 30, states that during the quarter considerable activity was shown in the lighting of the city. In the public streets, parks, and places 134 new gas lamps and 400 new electric lamps were placed and lighted, and 1,390 gas lamps were replaced by electric lamps. There are now 24,011 gas lamps, 2,275 electric lamps, and 152 naphtha lamps in use. The report also shows that seven and one-third miles of gas mains and seven and a half miles of electric subways were put down.

Door Furniture.—We have received a pamphlet containing a copy of some excellent photographic illustrations of work in door furniture and electric light accessories, made by Messrs. R. Crittall and Co., of 34, North street, Manchester-square, W. Among the varieties shown are different types of door handles, lock and finger plates, shutter knobs, lock case staples, lock cases, panels, grilles, etc. Special attention is, however, directed to the ornamental covers for switches and cut-outs, and which are of very artistic design. The pamphlet should be inspected by electric light contractors and others interested.

A Congress of Inventors.—It is announced that a congress of inventors and those interested in patents and trade-marks will be held in Chicago during the week commencing Monday, October 2, under the direction of the American Association of Inventors and Manufacturers, and in connection with a committee of the World's Congress Auxiliary of the Columbian Exposition. A large number of well-known men have promised either to attend and read papers or to prepare papers on different subjects relating to inventions and patents. Among the latter will be one by Dr. R. J. Gatling, president of the association.

Electric Fire Alarms.—The thin red pillars that stand at prominent places about our streets fulfil on the whole a most useful service, provided always that it is not a drunken vagabond or knave who rings the alarm, and also that the electric circuit is in good order. In cases of emergency, however, it is to be feared that the average citizen would not know just where to find the electric fire alarm, and a suggestion shortly to be carried out in New York is worthy of adopting at home also. This consists of an enamelled iron sign, with black letters on a white ground, fixed in every street to show the direction and distance of the nearest fire alarm.

Converters.—The Court of Orleans has given judgment in the action for infringement between Messrs. Zipernowsky, Déri, and Blathy on the one hand, and the Compagnie Internationale d'Electricité de Tours on the other. The Civil Tribunal of Tours declared in August, 1887, that the Gaulard and Gibbs transformers did not infringe the Zipernowsky transformers, but the Court of Orleans has now reversed that decision. The Court has decided that the Compagnie Internationale had infringed the patents taken out on March 20, 1885, and April 21, of the same year, by Zipernowsky, Déri, and Blathy, and has ordered them to pay damages, and confiscated 18 transformers at Tours.

Telephony.—The *Pall Mall Gazette* of yesterday states: "Mr. Arnold Morley is, we believe, to be pressed to divulge to the House of Commons the terms upon which he is about to convey to the private telephone companies the monopoly of supplying telephonic services to London and the larger provincial towns. It is high time, in the interest of the traders, that the present exorbitant charge in London of £20 per annum should be reduced to £5 or £6; and the representatives of commercial London in the House are anxious that the Government shall not be committed to any continued toleration of the present excessive charges. If the Postmaster-General concludes the contracts without taking the traders in the House into his confidence there will be a great outcry."

An Electric Piano.—At the Bristol Industrial Exhibition an electric piano is shown. The piano, according to a local paper, is so constructed that a current of electricity passes through the body of the performer while both hands are on the key board. The regulating switch enables the performer to cut off the current altogether, or to vary its *strength* at will. The arrangement does not affect the action, tone, or touch of the instrument. The current is supplied by dry cells. It is said that the performer, after long practice with this hygienic arrangement, may arise without feeling the usual fatigue and cramp. The keyboard is practically the only part of the instrument that is different in appearance from ordinary pianos, the difference being due to the metal faces of the keys.

Transformers.—A new catalogue has just been issued by the Leeds and London Electrical Engineering Company, Limited, of 15, St. Helen's-place, Bishopsgate-street, E.C., who are the concessionaires of the Lowrie-Hall system of generation and distribution of electricity. The Lowrie-Hall converter, which has been adopted in various central stations, is made in sizes ranging in power from 1 e.h.p. to 50 e.h.p., and the standard sizes are for transforming current at 2,000 volts or 1,000 volts to 100 volts, and 2,000 or 1,000 volts to a voltage of 50. The catalogue contains engravings of and text referring to large and small converters, converter cases, main fuses for stations, high-pressure fuses and frames, main switches, regulators, arc lamp switches, surface and junction boxes, etc.

Electric Hoists.—Nine electric hoists of the drum and winch head type have, says the *Engineering News*, been in use for more than two years on the wharves of Sanderson and Sons, at Brooklyn, which are used by the Wilson line of Transatlantic steamers. Each hoist is equipped with a General Electric 10 h.p. bipolar motor. When the hoists were first put in there was great opposition on the part of the workmen, and the owners themselves were somewhat doubtful as to the success of their venture. Experience has shown, however, that the electric hoists have many points of advantage over the steam machines which they superseded. In the matter of repairs, it is stated that the total expense for repairs on the nine hoists since they were erected, although they have been in daily service, amounts to less than £5, or an average annual expense of, say, 6s. per hoist.

The Azores Cable.—The cable from Lisbon to the Azores was set in operation on the 27th ult., at the submarine cable station at Carcavellos. The King, the Queen, and other members of the Royal family, the Prime Minister, and the Ministers of Public Works and War took the leading parts in the ceremony, which began with the exchange of various congratulatory messages between the King and Ministers and the leading authorities at Fayal, where the first connection of the cable has been made. After visiting the establishment of the British Submarine Company, the guests took luncheon in the large grounds of the company. Squadrons of cavalry were drawn up in the grounds, and several bands played at intervals. The negotiations have been carried on for some 20 years for laying this cable, and finally, after a keen competition last year with the French company, who secured the concession and allowed it to drop, it was given to the British company.

An Enterprising Village.—Probably none of our readers have ever heard of a place called Granville: for one thing it has only some 1,300 inhabitants, but in the State of Ohio is well known as an educational centre. We call attention to it in this place, not for the university or colleges, but because the municipality runs its own street arc lighting plant, and also because the place is connected with the chief town of the county—seven miles distant—by means of an electric railway running 20 trains daily between the two places. The dividing line between railroads and tramways would seem to become a very shadowy partition, when such enterprises as the above are successfully worked; and there should be hope yet for electric

traction even in this country if too many restrictions—legislative and financial—are not put upon it.

New Submarine Boat. — There has just been launched at Toulon a new submarine boat which is of greater dimensions than the "Gymnote" and the "Goubet." The new boat, which has been named the "Gustave-Zédé" in memory of the late naval constructor, M. Gustave-Zédé, has a displacement of 236 tons, and its machinery develops 720 h.p. The principle of working has been copied from the Whitehead torpedo. The act of immersion is effected by the operation of a horizontal rudder, which is put into action when the boat is travelling, and as soon as the machine stops the boat rises to the surface. The motive power is furnished by accumulators. At the launch the boat dived twice, and finally came to the surface with its equipment of 11 men standing on a platform. The boat was subsequently taken into the arsenal.

Electrical Work in Railroad Shops.—The recent putting on short time of nearly 16,000 men at the London and North Western Railway Company's Crewe works affects, of course, the electrical department also. Probably it will be news to our readers that there is such a branch of the company's establishment, apart altogether, that is, from the signalling and telegraph service. Some very good dynamos and motors have been made at Crewe, of course for employment in the company's work—either in the shops for power and lighting, etc., or outside, say, for instance, hotel, office, and warehouse lighting, and so on. When we last visited the works, a few months ago, there were several well designed machines to be seen in operation supplying current at different points for light and power (electric crane driving, *e.g.*), and though not highly painted or polished, they had a very solid appearance, as though they might be run safely for months at a time without overheating, even with a full load and rather more.

Underground Wires.—There has this week been a terrible cyclone in Georgia, resulting in the breakage of many overhead telegraph wires and interruption to communication. In New York great havoc was played among the telegraph wires between midnight and eight o'clock on Tuesday morning, when New York became virtually isolated from the rest of the country. The tide in the North River was so high that the water covered the telegraph wires. This would not have happened if the wires had been placed underground, as in Germany, where the cue in this direction was given to the Germans during the Franco-German War. The first lines laid underground there were military lines between Metz and Strasburg and the other fortified centres, and now the telegraph system of Germany stretches to almost every village from the capital. It is the work of Dr. von Stephan, head of the Imperial Post Office, who has laboured at the service since 1876. The same department works both the telegraphs and the telephones, the latter being carried on at a very low rate.

Tesla Out-Tesla'ed.—We are waiting with some degree of impatience the receipt of information with respect to a wonderful performance that was announced to take place at Cleveland, Ohio, a fortnight ago. Mr. J. E. de Leon—styled "the young electrician of Buffalo, and possible rival of Edison" (!!)—was, on the 13th ult., to give a notable exhibition at Forest City Park. A modest advertisement sets forth that he "handles the current with perfect ease and safety, walking on a bare wire charged from the arc lighting circuit, which is powerful enough to kill an ordinary man, his body meanwhile being brilliantly illuminated by the current which is conducted through it." Mr de Leon—who might safely be called Cœur de Leon—is a dangerous man, unless his morals are of the highest order, for evidently the electrocution system would fail in his case, and he might kill, murder, or slay with impunity. Stay, though; they are said to give morphine first, and that is possibly an antidote to Mr. de Leon's "apparatus, entirely of his own invention and construction, exhibiting inventive genius of a high order."

Excitability of the Muscles.—It is generally admitted that the electrical excitability of the muscles disappears a short time after death. This is true when the contraction of the muscles as a body is taken to determine the excitability, but it is insufficient to disclose very slight movements. M. d'Arsonval has for some years used for the purpose of studying the vibrations of the muscle a microphone, with magnetic regulation, termed a myophone. The myophone gives results before the excitation is sufficient to bring about contraction in a mass, and the intensity of the sound is greater if the muscle is strained by a spring. By the aid of this apparatus, M. d'Arsonval has found that the excitability of the nerves may continue for several hours after death. In order to prove this it is sufficient to attach the Achilles tendon of a rabbit to the myophone, and to excite the sciatic nerve by means of an intermittent current 50 or 100 times per second. Experiments in this direction show that the nerve can act upon the muscle without there being any apparent contraction, but simply molecular vibration, and that the death of the nerve takes place much slower than was believed.

Dangerous Rivals.—There has not so far been any serious trouble in this country arising out of competition between various trades for the work involved in carrying out an electrical installation; bricklayers, carpenters, and other artisans have left "electricians" and wiremen severely alone, thinking, perhaps, that a very large quantity of skill and information must be required for success in such a sphere of toil. On a huge insurance building now under erection in New York there is, however, at the present time a lively dispute going on between the wiremen and bricklayers as to which class of workmen is entitled to cut the holes in the brick walls through which the wires are to be brought. The respective unions have taken the matter into consideration, and since the work is not being done under contract the superintendent in charge of it has stopped operations, intending to allow the men to fight out the question themselves. It would be interesting to know whether the wiremen expect that bricklayers, if allowed to cut the walls, would thereby grow skilled enough to take an "electrician's" job, or whether the bricklayers consider that a wireman would find time enough and an inclination to spill mortar and hold a plumb-line with the "best of 'em." His power to make a good wire joint in that case might well be questioned.

An Electric Dredge.—An "electric" hydraulic dredge is proposed by Mr. E. J. Foord, to be used on portions of rivers where it is at present impossible to work by any appliance now employed. A New Zealand contemporary, the *Insurance, Mining, and Finance Journal*, states that the ordinary bucket and ladder dredges cannot, by reason of the heavy expenses entailed in repairs and the necessity of heavy and ponderous machinery required in such cases, work effectively on rough rocky bottoms or where the depth exceeds, say, 35ft. or 40ft. The plans proposed by Mr. Foord show several departures from any appliances at present in use for this description of work, and provide for any depth, say up to 60ft., being worked without trouble. The difference in the number of working parts in the two classes may first be noticed. On one of the dredges in use at Waipori or on the Clutha or Shotover

each ladder that carries about 40 buckets has nearly 700 working parts that cannot be oiled, and that are exposed to the action of water, sand, and dirt. These require almost constant attention and frequent renewal, and average a cost of 24s. a day to keep in repair. The steam-engine is also an expensive item, costing in many cases over £4 per day, and sometimes even more than this sum. These two items alone run away with the respectable sum of £1,635 for a year's work. By the proposed electric system £550 will do the same amount or even more work, as less repairing means more time to devote to paying work, and will leave a saving of £1,135.

Thinks it Doesn't Pay.—The current idea throughout the two hemispheres may be taken as certain that Edison has made, not a small, but a big fortune out of his inventions and discoveries. Probably his financial supporters have done so; indeed, that might be more confidently asserted. The great man's own expressions are to the effect that he is tired of it, and that it does *not* pay. These are his words: "I am not going to have anything to do again with anything that I have to get a patent on. Pioneering in any line of invention doesn't pay. For 20 years I have been fighting for 30 or 40 patents that I own. Out of all these I have been sustained in but two. The rest will probably be sustained 10 or 15 years after the patent rights expire. It is not that the patent laws are not right; it is because the practice in the courts is such that an inventor can get no satisfaction except by some defendant paying the inventor, or by sheer accident. This inventing business is a poor trade anyhow. If a man gets money it goes in litigation. The capitalists he has to fight have money enough to hold out for years where he can stand the expense for days only. Then the capitalists who have brought his invention into practical use, and paid the inventor in the corporation's stock, always slice from his share when they get into litigation on the score of patent rights, until finally his stock is all gone, and either one set of capitalists or the other have got the advantage of his mental toil and years of hard labour." In all which there is a large amount of truth and sound common sense, especially if the unfortunate man is a real inventor and not merely an adapter of other people's ideas.

The British Association.—The meeting of the British Association will commence at Nottingham on Wednesday week, the 13th inst., under the general presidency of Dr. Burdon Sanderson. The following gentlemen have accepted the positions of presidents of the different sections: Mr. R. T. Glazebrook, Dr. Emerson Reynolds, Mr. J. J. H. Teall, Rev. Dr. Canon Tristram, Mr. Henry Seebohm, Dr. J. S. Nicholson, Mr. Jeremiah Head, and Dr. H. Robert Munro. Amongst the subjects to be considered by the sections are: Electrical standards, meteorological observations on Ben Nevis, the application of photography to meteorology, calculation of tables of certain mathematical functions, recording direct intensity of solar radiation, wave-length tables of the spectra of the elements, an international standard for iron and steel analyses, the direct formation of haloids from pure materials, action of light on dyed colours, the discharge of electricity from points, comparing and reducing magnetic observations, optical constants of lenses, ultra-violet rays of the spectrum, meteoric dust, and the rate of increase of underground temperature. Among some of the other subjects which will probably be introduced and discussed will be the following: In Section A (mathematics and physics) the question of the national physical laboratory, of the central publication of physical papers, of magnetic and other units, and of mechanical connection between ether and matter will probably be raised. In Section G (mechanical science), Mr. Keep (of Messrs. Manlove, Alliott, and Co.) will discuss thermal storage in connection with the utilisation of refuse, and Mr. Warner is expected to describe destructors.

Electric Quackery.—The "medical electrician" has come up very prominently into notice at the World's Fair, and it won't be his fault if a battle does not rage over his mercenary and sordid carcase. The administrative officers of the exhibition made a very big mistake when they allowed such abominations as "medical belts" to occupy any space at all, but probably they were not blind to the financial ability and resources of electric quacks. Now that a jury of competent men—who know respectable science when they see it—have begun to consider the exhibits for report and awards, there is a natural reluctance on their part to touch the unclean thing; but the American electrical journals are—very rightly—loud in their denunciations of such weak-kneed policy, and call upon the officials to insist upon a full examination of all exhibits as a matter of common fairness. It is to be hoped, says New York *Electricity*, that the jurors will sit on these frauds, and *sit hard*. So far as the fakirs themselves are concerned, they have had the hardihood to ask for these judicial reports, and have induced some of their fellow-exhibitors to sign the following choice petition, addressed to Prof. Barrett, the head of the Electrical Department: "Dear Sir,—There having been more or less said against the electric belts exhibited in this building, and referring to them as fakes, we, the undersigned, respectfully request that said belts be submitted to a jury for them to test same for voltage, amperage, and internal resistance. We ask this to sustain you in your action in giving them a space, and also in justice to themselves as exhibitors. There are many electrical appliances and belts that are fakes, from which no current can be obtained, and those that do not have merit should be known, especially the exhibitors that you have admitted in this Electrical Building in the World's Fair." As to which it might be said—*Arcades ambo.*

Electricity on a Pyramid.—In his autobiography the late Sir W. Siemens relates an amusing anecdote. An Arab called his attention to the fact that when at the top of the Pyramid of Cheops, when he raised his hand with fingers outspread, an acute singing note was heard, the sound ceasing as soon as he let his hand fall. "I found his assertion," he writes, "to be true. As soon as I raised one of my own fingers above my head, I felt a prickling in the fingers. That this could only be caused by an electrical phenomenon was proved by the slight electric shock felt on trying to drink out of a wine-bottle. So I wrapped a full bottle of wine that I had with me in damp paper, and thus converted it into a Leyden bottle, which was soon strongly charged with electricity by the simple device of holding it high above my head. The Arabs had already become distrustful on seeing small lightnings, as it were, issue from the wine-bottles held up by myself and companions, and now held a brief consultation. Suddenly, at a given signal, each of my companions was seized by the guide who had led him up, who now tried to force him to go down again. I myself was standing at the very top of the pyramid, when the sheikh of the Arabs came to me and told me, through my interpreter, that the Arabs had determined that we were at once to leave the pyramid, because we were practising magic, and it might damage their chance of their earning a living. On my refusing to obey orders, the sheikh caught hold of my left hand. I had awaited this moment, and held up my right hand with the bottle in the attitude of a magician, afterwards lowering it slowly towards the point of the sheikh's nose. When quite close

to that feature I felt a violent shock run through the bottle to my own arm, and was certain that the sheikh must have received the equivalent. At any rate, he fell speechless on the stones, and a few anxious moments passed before he rose suddenly with a loud cry, and sprang down the gigantic steps of the pyramid with long strides. The Arabs seeing this, and excited by the sheikh's constant cries of 'Magic! magic'' released my companions and followed their leader, leaving us complete masters of the pyramid."

Edinburgh and Telephony.—The Glasgow Corporation have asked the Edinburgh Town Council to support the application of the former to the Postmaster-General for a license to establish a telephone system. This was considered at a meeting of the Edinburgh Council on Tuesday. Lord-Provost Russell said that in sending this matter to his committee, the Council ought to give the committee powers to enquire into the whole subject. They had seen by the newspapers that the Postmaster-General had given a rather evasive answer to the Glasgow Corporation. He thought that Corporation deserved their thanks for bringing this question to an issue. A Special Committee of the House of Commons had recently reported that telephone undertakers, which practically meant one company, were to have the right to go under the streets. They felt this bad enough in connection with their own trusts, but if they had to do with a body which was hostile to them, and which had led them to considerable expense the other day in opposing them before the House of Commons, they would have many a controversy if they had to fight them every time they opened a street and spoiled it. It seemed to him the Government, by their committee, were forcing municipalities to consider whether they should take up the question of taking over the telephone service or not. They must investigate and see where they were. If the Postmaster-General refused the application, and made a fresh agreement with the telephone companies, it would mean that all the corporations in Scotland should appeal to the Government; they could not submit to the telephone companies destroying the streets. He moved that the matter be remitted. Bailie M'Donald, in seconding, said he would like powers given to the committee to support the Glasgow Corporation in preventing the company from taking possession of the streets. The Lord Provost said the Council might be willing to give the committee powers in handling the question in Parliament. After further conversation the matter was remitted to the committee.

Telephony at Glasgow.—The Municipality of Glasgow, having applied for a license to establish a telephone exchange within that city, has received a reply stating that the Postmaster General observes that the application refers to a recommendation of the recent Joint Committee on Electric Powers, and he thinks it right to inform them that he has received a communication on the subject from the Association of Municipal Corporations. The question whether measures shall be taken, and, if so, what measures, to give effect to this recommendation of the joint committee, must, he says, engage the very careful consideration of her Majesty's Government, and the association has been informed that no final step will be taken until they have been afforded an opportunity of expressing their views. In view of the intimate relation between the question of fresh licenses for telephone exchange business and that of statutory powers for laying telephone wires underground, the Postmaster-General does not feel that he can at present arrive at any decision on the application from Glasgow. Not content with this reply, a deputation of the Glasgow Corporation had an interview with the Postmaster-General on Wednesday evening. After hearing the views of some of the members of the Corporation, Mr. Arnold Morley, in reply, said that the Government would not at all interfere with the freedom of municipal enterprise with regard to any matters it could legitimately control for the public interest. The telephone, however, was not a part of municipal business, but belonged to the telegraph system, which was conducted by the State. It was not confined to the municipal area, like water, gas, or tramway works. In continuance of the policy of the late Government, he was now engaged in purchasing the trunk lines of the telephone system, and until that was completed it was impossible to consider the question raised by the present application. The movement might possibly develop into the Government taking over their entire management, but any step taken in advance in local districts would complicate matters. He was strongly in favour of further powers being given to the municipalities to manage affairs which were strictly municipal, but he could not enter into further details on the question raised by the deputation until the agreement as to the trunk telephone lines had been finally settled.

Mexico and California.—According to the *Scientific American*, electrical enterprise is very progressive in Mexico. That this is so we are in a position to know, but the English work in the matter has been carried on very quietly, and those engaged in it have requested silence. We are unable, then, to do more at present than to quote our contemporary, which says: "Among the notable industrial enterprises recently inaugurated in Mexico is the electric lighting of the city of Guadalajara. The plant utilises the famous Juanacatlan waterfalls, which are situated about 18 miles from Guadalajara. The Thomson-Houston generators are actuated by Leffel turbines, the head of water being 58ft. Three turbines of 550 h.p. are used. The dynamos for arc lighting have capacity each for 50 arc lights of 2,000 c.p. The current strength is 10 amperes, and consequently the maximum voltage is 2,500. The incandescent dynamo consumes about 750 h.p. and yields approximately 350 amperes at 1,000 volts, or say 350 kilowatts. The voltage is increased from 1,000 to 5,000 volts by means of 10 step-up transformers. They transform the energy of the dynamo at an efficiency of about 98 per cent., delivering to the line, therefore, 98 per cent. of the energy supplied them and at five times the pressure. The high-pressure incandescent circuit is reduced to 1,000 volts by step-down transformers at Guadalajara, 17 miles from the source of electricity. The installation of the San Antonio Light and Power Company, of Pomona, California, possesses many feature of interest. The current is carried 28 miles under the enormous pressure of 10,000 volts. The generators are of the standard 120-kilowatt, 12-pole, 1,000-volt Westinghouse alternator, which delivers current at 7,200 alternations on being driven at 600 revolutions per minute. The generators are coupled direct to Pelton waterwheels, the head being 395ft. The 1,000-volt current is taken to the switchboard and from there to the bank of step-up transformers, from which the current is delivered under a pressure of 10,000 volts. One circuit is carried to Pomona, 15 miles, and the other to San Bernardino, 28 miles away. The wire used is No. 7 B. & S. hard-drawn bare copper wire, and is carefully supported on poles by insulators specially designed for this plant. A potential of 9,500 volts is received in Pomona and 9,000 in San Bernardino. The pressure on the city lines is maintained at 1,000 volts."

ALTERNATE-CURRENT TRANSFORMER DESIGN.

BY R. W. WEEKES, WHIT.SCH., A.M.I.C.E.

(Concluded from page 55.)

Alteration of Efficiency with Frequency.—The selection of the most economical frequency for alternate-current working from supply stations is influenced by so many different considerations that the present want of uniformity in this respect can hardly be a matter for surprise. It is most important that each company using the alternate-current system should arrange all their generating plant to work at the same number of cycles per second. If the prime movers are suitable, the alternators can then be run in parallel with each other, and even if the engine will not allow of parallel running, this uniformity in the frequency given by the different alternators in the same station is advantageous. Beyond this the matter has been largely left in the hands of the manufacturers. So we find that in America the high frequency of 133 periods per second has been extensively used because a large manufacturing company adopted it as their standard. In England, the practice is to use generally frequencies between 75 and 100, whereas on the Continent much lower values have been successfully adopted. It is out of the range of the present articles to consider the whole grounds for and against either extreme in the adoption of a standard frequency. Roughly, the higher values tend to slightly reduce the first cost of the generating plant, and the use of motors is as yet only commercially possible where low frequencies are used. Whichever may be universally more economical, the fact remains that transformers have to be used, and it is the effect on the economy of the transformer that we have to consider.

From equation (1) the potential difference, as measured by a Cardew voltmeter, at the terminals of a transformer on open circuit is

$$e = 4{\cdot}45 \text{ F } \tau \, n \, 10^{-8},$$

and F, the total flux, may be written $\mathfrak{B}\, a$ where $\mathfrak{B}$ equals the maximum induction, and a equals the cross-section of the iron core. Hence

$$e = 4{\cdot}45 \, \mathfrak{B} \, a \, \tau \, n \, 10^{-8}.$$

With a transformer having a certain transforming ratio, say, 2,000 / 100 volts, the voltage, e, required on the secondary will be the same whatever the frequency of the alternating current supply. This ensures that e shall be a constant quantity however the frequency may vary on different supply mains. We may therefore consider e as constant, and the quantities a and τ on the other side are also constants for any given transformer. Hence, if n changes, there must be an inverse change in $\mathfrak{B}$ to keep the E.M.F up to the same value, or, in other words, $\mathfrak{B}\, n = \mathfrak{B}_1 \, n_1$, where $\mathfrak{B}_1$ n_1 are the new values of the induction and frequency respectively. Hence, in the transformers designed above for 100 $\sim$ the induction required would be doubled if the frequency were dropped to 50 $\sim$. This alteration in induction alters the value of the iron losses, and hence affects the efficiency of the transformer

The subject of the loss in iron wire and plates when subjected to a magnetising force which varies has been a source of many investigations of late years. The conclusions arrived at by the many able experimentors on this subject are: first, that the hysteresis loss in the iron for any given induction is directly proportional to the number of reversals; second, from the many curves obtained it is found that the results are fairly represented by an equation containing $\mathfrak{B}$ to the 1·6th power. Hence the loss in hysteresis only may be expressed by the equation:

$$W_H = a \, n \, \mathfrak{B}^{1{\cdot}6} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where W_H = the watts lost per pound of iron;
a is a constant depending on the iron used;
n = the frequency;
$\mathfrak{B}$ = the maximum induction.

The other part of the iron loss is that due to Foucault currents in the iron plates

The determination of formulæ for calculation of these losses in plates requires some elementary calculus, and certain assumptions as to the path taken by the current have to be made. It will be sufficient to take the generally accepted formula for iron plate, which, when reduced to watts per pound of iron, becomes, roughly

$$W_F = 5 \, (t \, \mathfrak{B} \, n)^2 \, 10^{-9} \quad . \quad . \quad . \quad . \quad (6)$$

at 100deg. F., where t = the thickness of the plate in inches and $\mathfrak{B}$ and n have values as above. Now, for any given transformer the square of the thickness of the plates may be merged into the constant, and the formula becomes

$$W_F = b \, (\mathfrak{B} \, n)^2,$$

where b is a constant. Hence the total loss is given by

$$W_H + W_F = a \, n \, \mathfrak{B}^{1{\cdot}6} + b \, (n \, \mathfrak{B})^2.$$

As n occurs in different powers in the two terms on the right-hand side of this equation, it will be readily seen that any curve drawn for the total iron losses for a given frequency cannot be used at any other frequency. It is, however, quite possible by careful experiments to verify the equation given above. This can best be done by taking power readings of the iron losses when the frequency is varied very considerably. Then the different set of results can be analysed by simple algebra. This can be more readily done with plates of greater thickness than those used in ordinary work, as in that case the expression for the eddy currents is a larger proportion of the total loss. The approximate truth of this formula and the corresponding expression for the eddy-current loss per pound of iron being established, we can proceed to divide the curve of iron losses, Fig. 4, into its two components. To do this, the loss in watts per pound for inductions varying from $\mathfrak{B}$ = 8,000 to $\mathfrak{B}$ = 1,000 must be calculated from (6), and the figures obtained when subtracted from the ordinates of curve, Fig. 4, leave the hysteresis loss per pound at 100 cycles per second. Thus at $\mathfrak{B}$ = 6,000 for 10 mil plates we have

$$\begin{aligned} W_F &= 5 \, (t \, \mathfrak{B} \, n)^2 \, 10^{-9} \\ &= 5 \times (\cdot 01 \times 6{,}000 \times 100)^2 \times 10^{-9} \\ &= 5 \times 6{,}000 \times 6{,}000 \times 10^{-9} \\ &= \cdot 180 \text{ watt per pound.} \end{aligned}$$

Now the ordinate on Curve 4 when $\mathfrak{B}$ = 6,000 is 1·70. Therefore the hysteresis loss alone is 1·70 – ·18 = 1·52 watts per pound of iron.

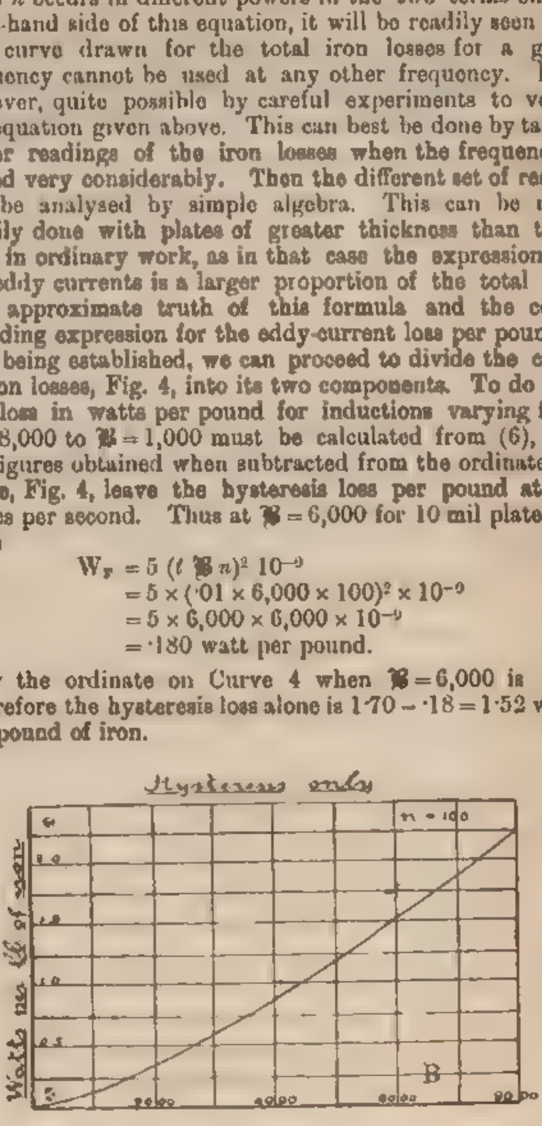

Fig. 25.

Doing this for all the points, and plotting the results in a curve as before, we obtain Fig. 25, which gives the loss per pound of iron due to hysteresis only, at 100 $\sim$. From this the losses at other frequencies can be obtained by simple proportion. It will be found on trial that the curve thus obtained is not quite in uniformity with the equation of $\mathfrak{B}$ to the 1·6th power. This is due to some qualities of the iron from which the original results were obtained. To explain fully the method of working with this curve it will be well to take the design No. 1 and to calculate the iron losses for that transformer when working at frequencies of 50, 75, 100, and 130 respectively.

We have from the table of results that for n = 100 $\mathfrak{B}$ = 3,580 at the normal voltage; now $n \, \mathfrak{B} = n_1 \, \mathfrak{B}_1$, so that

$$\mathfrak{B}_1 \text{ for } n_1 = 50 = \frac{3{,}580 \times 100}{50} = 7{,}160.$$

In the same way as n_1 = 75

$$\mathfrak{B}_1 = \frac{3{,}580 \times 100}{75} = 4{,}800.$$

and at n_1 = 130, $\mathfrak{B}_1$ = 2,770.

We will in this case tabulate the results, as errors can then easily be seen and avoided. The fact that the hysteresis loss is directly proportional to the frequency now enables us to determine the total hysteresis loss in each of the above cases. Thus at $\mathfrak{B} = 7{,}160$ the loss per pound at 100 ⁀‿ is, from Fig. 25, 1·94 watts per pound. ∴ the loss at 50 ⁀‿ in 172·5lb. will be

$$W_H = \frac{1{\cdot}94 \times 172{\cdot}5 \times 50}{100} = 168 \text{ watts.}$$

Table of Iron Losses and No Load Currents for Shell Type Six Kilowatt Transformer, Design (1), at Different Frequencies.

Frequency.	50	75	100	130
$\mathfrak{B}$	7,160	4,800	3,580	2,770
Hysteresis watts	168	146	133·8	124
Foucault watts	11	11	11	11
Total loss	179	157	144·8	135
μ	2,650	2,300	1,960	1,680
i_μ	·127	·098	·0858	·0772
i_H	·089	·078	·0724	·0675
i	·155	·123	·112	·1025
Iron loss per cent.	2·98	2·62	2·42	2·25
i per cent.	5·16	4·16	3·72	3·42
Power factor	·57	·63	·648	·658

In the same way for $\mathfrak{B} = 4{,}800$ and $n = 75$,

$$W_H = \frac{1{\cdot}125 \times 172{\cdot}5 \times 75}{100} = 146 \text{ watts.}$$

The rest of the values of W_H calculated in the same way are 133·8 for $n = 100$, and 124 watts for $n = 130$.

The Foucault loss is got from the formula (6)—*i.e.*, watts per pound $= 5\,(t\,\mathfrak{B}\,n)^2\,10^{-9}$.

In this transformer 10-mil plates were used, and the iron weighed 172·5lb.

Hence, $W_F = 172{\cdot}5 \times 5 \times (\cdot01 \times 7{,}160 \times 50)^2 \times 10^{-9}$.
$= 11$ watts at 50 frequency.

But we saw above that $\mathfrak{B}\,n$ was always a constant if the voltage at the terminals of the transformer was not varied. So the eddy current loss must also be a constant for all frequencies, as these two quantities are the only variables in the equation used above. Filling up the list, the total iron loss in each case can now be obtained by addition. It will be immediately observed that this increases rapidly with a decrease of the frequency. By halving the value of n, we have in this transformer increased the iron losses by some 25 per cent. Hence, if the transformer was designed to the heating limit at a frequency of 100, it would get too hot when placed on a circuit supplied at 50 frequency. This change in the iron loss is more marked in transformers using a higher induction than in the present design. To complete the list, we now require to find the exciting current at the different frequencies. The values of μ for each induction can be at once taken from the curve Fig. 5. Then i_μ from (2) $= \dfrac{\mathfrak{B}\,l}{\mu\,\tau_1 \times 1{\cdot}76}$. As four values have to be calculated and part of the right-hand side, $\dfrac{l}{\tau_1 \times 1{\cdot}76}$, is common to all cases, it may conveniently be worked out separately.

In this transformer, l, the mean length of the iron circuit was 123cm. and $\tau_1 = 1{,}490$,

therefore $$\frac{l}{\tau_1 \times 1{\cdot}76} = \cdot0468\,;$$

and $$i_\mu = \frac{\mathfrak{B}}{\mu} \times \cdot0468.$$

Thus at $n = 50$, $\mathfrak{B} = 7{,}160$, and $\mu = 2{,}650$,

$$\therefore i_\mu = \frac{7{,}160}{2{,}650} \times \cdot0468$$

$$= \cdot127 \text{ ampere.}$$

The rest can be worked out in exactly the same way. The values of i_H are obtained by dividing the total iron loss by the voltage on the primary winding, which in this case was 2,000.

The magnetising current $i = \sqrt{i_H{}^2 + i_\mu{}^2}$, so in the first case $$i = \sqrt{\cdot089^2 \times \cdot127^2}$$
$\cdot155$ ampere.

Completing the other values in the same way, it will then be better for reference to add two more lines, showing the iron loss and magnetising current respectively in percentages of the full-load values. The ratio of these two gives the power factor, which will be seen to fall with the frequency. This is not always so, but depends largely on the shape of the μ curve of the iron used.

The general conclusions from this investigation are briefly as follows: When the frequency at which the transformer is used is decreased, the loss in iron is increased, and there is consequently a fall in the efficiency of the transformer. (It must be remembered when considering the loss in the iron of a transformer, that although the loss may be a comparatively small percentage of the maximum output, it is a large percentage of the average load. Thus, while an increase of 25 per cent.—*i.e.*, from 2·42 to 2·98 per cent.—does not appear much, it may make the difference between profit and no profit in the central station accounts.) Also the larger iron loss will increase the final temperature of the transformer. So, for low frequencies, more cooling surface should be provided. In other words, a larger transformer is required. This, of course, will raise the cost of the instrument for a given output. On the other hand, a transformer designed to have a good efficiency at a low frequency can be used more economically at higher frequencies, but the cost of manufacture will then be the prohibitive factor.

Quality of Iron.—This is the indeterminate quantity which causes uncertainty in the manufacture of transformers. Every batch of iron received should be kept separate, and the tests of the transformers made from it then give a ready check on any falling off in the quality. The curves given (Figs. 4 and 5), which have been used in all the designs above, were taken from a transformer actually made. The iron was a better quality than the average brands of plate, but was by no means the best that can be obtained. With careful selection, iron can be found with which the losses per pound come out quite 30 per cent. below those given in Curve 4. It is in the permeability curve that the greater difference is noted with these superior qualities of iron. This curve, then, rises much more rapidly at low inductions, and the permeability throughout may be some 80 per cent. higher than the values given in Curve 5. The higher permeability reduces the current required to magnetise the iron, and consequently the power factor is increased. On referring to Dr. Fleming's list of tests, it will be seen that in one case he obtained a power factor as high as ·92. A special brand of mild steel is said to be used in this transformer, which must have a very high permeability to account for such a power factor.

Transformers for Different Methods of Supply.—The transformers used in lighting individual houses are very seldom worked at full load, and the average load is so small that the heating effect of the current in the copper circuit may be almost neglected. The transformer should, of course, be able to stand the full current for some hours without undue rise of temperature. The all-day efficiency is then fixed by the iron loss, and but for the regulation the copper might be reduced to save first cost. The sub-station system of supply is now coming into more general use. In this system the consumers are connected on to a low-tension network, which is fed at different places by transformers in sub-stations. In this way, even if the whole of the transformers are left continuously on the mains, a much higher load factor is obtained, owing to the different classes of buildings supplied. That is to say, the average load is a larger proportion of the maximum load, and hence the transformer is worked more economically. To still further increase the economy, arrangements are made for reducing the number of transformers in connection with the main as the load diminishes. So in these transformers and in those used in power transmission on a large scale, the watts wasted in the copper form a good proportion of the total loss. As the heat generated in the copper is liable to [illegible] the insulation, it is advisable in the large trans[illegible] for central-station work to keep the [illegible] copper lower than in small t[illegible] installation work.

ON THE TRANSMISSION OF ELECTRIC SIGNALS THROUGH SPACE.*

BY W. H. PREECE, F.R.S.

(*Concluded from page 184.*)

It is very necessary to be able to distinguish or separate these earth currents from currents due to induction, for they are very apt to give false effects and to lead to erroneous conclusions. This is easily done, if the instrument be sensitive enough, by making the primary current continuous when the earth current also becomes continuous, while induction currents are momentary, and are observed only during the rapid rise or fall of the inducing cause.

2. Electrostatic Induction.

When a body, A, is electrified by any means and isolated in a dielectric, it establishes an electric field about it. Lines of electric force are projected from it in every direction; and if in the direction of any of these lines of force there is placed another similar body, B, it is also electrified by induction. If B be placed in connection with earth or with a condenser, or with any large body, then the charge of the same sign as A is conveyed away, and B remains electrified in the opposite sense to A, and to the same amount. A and B are seats of electric force. They form a stress, and are the ends of a line of force. The dielectric between them is displaced or polarised electrically. It is in a state of strain, and remains so as long as A remains charged, but if A be discharged, or have its charge reversed or varied, then similar changes occur in B and through the dielectric separating them.

Fig. 1.

If A, Fig. 1, be a flat disc electrified positively and be placed inside a ring, B, then the ring becomes the termination of lines of electric force, and the sum of their terminal negative charges is equal to the whole positive charge of A. A may, in each of the above cases, be the section of a continuous wire or conductor forming part of a complete circuit.

Fig. 2.—During Charge.

The charge on A may be due to the electric force of a primary current, while in the secondary conductor, B, the displaced charge in flowing to earth establishes a momentary current whose direction and duration depends on the current of A, and on its rate of variation.

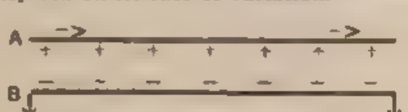

Fig. 3.—Steady Current.

The strained state of the dielectric and the charges on A and B remain quiescent so long as the current flows steadily; but if the primary current ceases, then we have secondary currents in each conductor, as shown by the arrows, and flowing until equilibrium is restored.

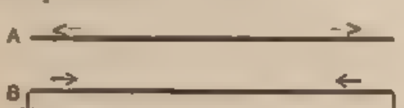

Fig. 4.—During Discharge.

The secondary currents due to discharge, flow in opposite directions at each end, and there is always some intermediate zero point.

* *Paper read at the Chicago Exhibition.*

It is thus easy in long circuits by observing their direction to differentiate currents of induction due to electric displacement from those due to electromagnetic disturbance.

The dielectric plays just as important a part in the electrical operations that occur as do the conductors. Its molecular disturbance cannot be neglected. It is subject to strain and variations of displacement in one direction, while it is permeated by a wave of energy in another direction—viz., in the direction of the primary current. In fact, it is a question much discussed at the present day whether the prime action in all current effects is not this wave or flux of energy passing longitudinally through the dielectric in the direction of its length, and that nothing whatever passes through the conductors, which are mere passive agents in the matter, wasting energy but not transmitting it.

There are two views of the formation and support of a current. The one following Faraday regards it as the continuous discharge of the contiguous charged molecules of the conductor, the action originating in and being propagated uniformly throughout the conductor. The dielectric plays only a secondary part. The other derived from Maxwell by Poynting regards a current as the consequence of the propagation of a wave of electrical energy through the dielectric in the direction of the line, and which reaches the wire from the exterior. The conductor plays a secondary part—it simply dissipates the energy conveyed by the dielectric. The current is set up on the

Fig. 5.

surface, and it penetrates the interior comparatively slowly, while its distribution in any given sectional area of the conductor is not uniform.

The truth lies probably in a combination of each view. The dielectric is as much an essential agent in the action as the conductor, and in each plane, perpendicular to the current, the charge and discharge of contiguous molecules, the formation of an electric field, the formation of a magnetic field, the flow of energy across this plane and parallel to the conductor, its dissipation as heat in the conductor, are all simultaneous and self-dependent, and equally concerned in the final result.

In a complete metallic loop the energy is propagated in the dielectric between the wires, it is dissipated in the wires, there are longitudinal waves propagated through the dielectric parallel to the wires, and there are other circular electromagnetic waves emanating from each conductor as a centre and flowing as a resultant in planes perpendicular to the wires. Thus there are lines of electric force, lines of magnetic force, and lines of energy flow. The first determine displacement, and are controlled by electrostatic capacity; the second determine electromagnetic disturbance, and are controlled by inductance; the third determine transformation of energy, and are controlled by resistance. Time enters into the consideration of the longitudinal speed of the energy flow through the system, of the electromagnetic disturbance through the dielectric at right angles to this flow, of the rise and fall of the current at each point of the circuit, of the character of the current, whether continuous or alternating, and, if alternating, of the frequency of the complete alternations.

The effects of electrostatic induction do not play an important part in the enquiry immediately before us, but they are of great consequence in considering questions of speed of signalling in submarine cables, and clearness of speech in long-distance telephony.

3. Electromagnetic Induction.

Magnetic force is that which produces or tends to produce polarisation in magnetisable matter—viz., iron, nickel

and cobalt—and electromagnetic disturbance in non-magnetisable matter and the other. It excites lines of magnetic force and becomes a stress. An electric current in a conductor is a seat of magnetic force. It establishes in its neighbourhood a magnetic field

The lines of force, Fig. 5, in this field are equivalent to circles in a plane perpendicular to the direction of the current, which, during the rise of the current in A, flow outwards, and during the fall of the current flow inwards, like the waves on the surface of smooth water when a stone is dropped into it, but moving with the speed of light. Thus any other linear conductor, B, placed in this field parallel to A, is cut at right angles to itself by these lines of force—in one direction as the current rises, and in the other direction as the current falls. The projection of lines of magnetic force through a linear conductor in a direction perpendicular to its length excites electric force in that conductor; and, if the conductor be continuous and form part of a circuit, it establishes voltage, and, therefore, a current in this secondary circuit. Now, the strength of this secondary current, C_2, depends on the strength of the primary current, C_1, on the rate at which it rises or falls $\left(\frac{dC}{dt}\right)$, on the resistance of the secondary circuit, r_2, on the distance which separates the two circuits, d, and on

FIG. 6.

the length of the inductive system, l. The direction of the secondary current everywhere is reverse to that of the primary during its rise and in the same direction during its fall.

If the two circuits are separate and independent, this action between them is called mutual induction; but if B be a part of the same circuit, A, it is called self-induction The amount of induction is dependent also on the magnetic elements present in the conductors and in the space between them. This is measurable in its own unit (which it is proposed to call "henry"), is called inductance, and is usually indicated by L or M, according as the question dealt with is self or mutual inductance.

EXPERIMENTAL INVESTIGATION.

Since 1885 I have had a vast number of experiments made to thresh out the laws and conditions that determine the distance at which these magnetic disturbances can be usefully evident. The instrument used to receive these signals has been generally the telephone, but many absolute measurements have been made with a very sensitive reflecting galvanometer. The judgment required to determine the relative intensity of sound in a telephone is a very variable and uncertain agent, even though many observers be utilised and the same experimenters perform with the same apparatus. But this does not apply to the observation of the limiting audible intensity of signals. The point where sound ceases is obtained with concordant and satisfactory results when the mean judgment of several observers using the same telephone is made use of. I never use less than three observers, and sometimes have employed as many as seven. By this means we observe by what I call the average normal ear.

I. To prove that the effects were due to electromagnetic induction.

Conductors of copper wire insulated with guttapercha were formed into quarter-mile squares, Fig. 6, and laid on a level plain at a distance of a quarter of a mile apart.

Arrangements were made for sending vibratory or alternating currents which could be broken into Morse signals by means of a telegraph key. Telephones were used as receivers, which transformed these signals into buzzing dots and dashes.

On closing the circuit in one square and sending signals, conversation could be readily held between the two operators by means of the Morse code. Now, obviously, earth conduction could play no part in this transmission of signals, for the squares were insulated throughout from the earth.

Next, in order to ascertain to what extent, if any, electrostatic effects were observable, one pole of the battery used was put to earth, and the further end of each square was disconnected.

Now, by this arrangement the mean electric force of one square was doubled, as compared with the former experiment, where the circuit was completed, but no effect was observed in the second square, either in the receiving telephone or with the reflecting galvanometer. The squares were even superposed at a distance of only 15ft. apart, the upper one being suspended on poles, and the lower one laying on the ground, but without any result. Hence, the effect observed in this experiment was clearly due to electromagnetic induction.

II. To prove that the effects increased directly with the strength of the primary current used and diminished with the resistance of the secondary current.

(a) Two quarter-mile squares of insulated wire were opposed to one another, and the distances between the front faces varied from eight yards to 192. Current of one and two amperes respectively were sent into one square, and the induced effect in the second square with two amperes was invariably twice that with one ampere. The measurements were made with a reflecting galvanometer.

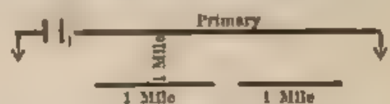

FIG. 7.

(b) Open wires were placed parallel to one another, and a mile apart horizontally, Fig. 7. The primary circuit was two miles long. The other, the secondary current, was divided into two equal one mile lengths. With a primary current of ·22 ampere the vibrations were just audible in a telephone fixed to either of the single-mile lengths of the secondary, the total resistance in the latter circuit being 85 ohms. With a similar current (·22 ampere) in the primary and the secondaries joined into a two-mile length the same limit of audibility was reached when the resistance in the secondary was doubled—that is, it was raised to 170 ohms. Next, the current in the primary was doubled, or increased to ·44 ampere, and with a one-mile secondary the total resistance had to be doubled in order to reach the same limit. Finally, when the current in the primary was raised to ·88 ampere—four times the original figure—then the same limit was reached when the resistance was quadrupled.

III. To find how the effects varied with the length of the inductive system and with the distance separating them.

The law for variation of length and distance is very complicated and depends wholly on the form of the circuit and its various reactions. It may be briefly summarised as follows, but the experiments upon which these conclusions are drawn are given as an appendix, together with the equations developed from them.

Let l = length and d = distance apart of two conductors assumed equal and similar, then

(a) With two infinitely long straight lines it varies inversely as d alone.

(b) With one infinitely long straight wire, and a wire of finite length, it varies as $\frac{l}{d}$.

(c) With one infinitely long straight wire opposed to a rectangle, the law becomes

$$2\,l\left(\frac{1}{d}-\frac{1}{D}\right)\mathrm{M},$$

where D is the distance from the face to the back of the rectangle.

(d) Where the rectangle is replaced by a square, the above formula becomes

$$\frac{2\,l^2}{d\,(l+d)}.$$

(*e*) With a rectilinear wire of finite length opposed to a square, the length of the former being equal to the face of the latter, it varies as

$$\frac{l}{d}.$$

(*f*) With two squares of equal dimensions opposed to one another, Fig. 9, the effect varies, where l is great compared with d, as

$$\frac{l}{\sqrt{d}}$$

but when d exceeds half l, it varies as

$$\frac{l}{d}.$$

Fig. 8.

Note.—With cases *c*, *d*, *e*, and *f*, if d became very great, the effect would diminish and ultimately disappear, owing to the opposing current in the back of the square having practically the same influence as that in the front. When d is very great, the effects due to a and a_1 may be neglected.

(*g*) With two rectilinear wires of equal length, if the effect of the magnetic waves due to the return current through the earth be neglected, then when l is great compared with d it varies as

$$\frac{l}{d},$$

but when d is great compared with l, it varies as

$$\frac{l^2}{d^2}.$$

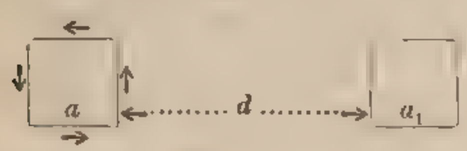

Fig. 9.

The complete formula for the aerial portion of the circuit is as follows:

Let C_1 = current through primary;
q_2 = quantity induced in secondary;
r_2 = resistance of secondary;
l = length of either wire;
d = distance between wires;
then M constant in C.G.S. units,

$$q^2 = \frac{c_1}{r_2} \frac{\sqrt{l^2 + d^2} - d}{d} \times M.$$

The complete formula must, of course, allow for the reverse effect of the return circuit through the earth. I hope later to obtain sufficient data on which to base such a formula.

The value of M, obtained from a series of experiments on two parallel squares of wire 1,200 yards in length and five yards apart, was found to be ·003.

(*h*) The difference in water as compared with air is not very marked. In certain experiments, which were considered reliable, and which appear on Table I., it was about 6 per cent. more in the air than in water. The result was probably due to the magnetic waves being degraded into electrical currents in traversing the conducting sea-water.

IV. Practical Experiments.

The Bristol Channel proved a very convenient locality to test the practicability of communicating across a distance of three and five miles without any intermediate conductors. Two islands, the Flat Holm and the Steep Holm, lie off Penarth and Lavernock Point, near Cardiff, the former having a lighthouse upon it. On the shore two thick copper wires combined in one circuit were suspended on poles for a distance of 1,267 yards, the circuit being completed by the earth. On the sands at low-water mark, 600 yards from this primary circuit and parallel to it, two guttapercha-covered copper wires and one bare copper wire were laid down, their ends being buried in the ground by means of bars driven in the sand.

One of the guttapercha wires was lashed to an iron wire to represent a cable. These wires were periodically covered by the tide, which rises here at spring to 33ft. On the Flat Holm, 3·1 miles away, another guttapercha-covered copper wire was laid for a length of 600 yards.

There was also a small steam launch having on board several lengths of guttapercha-covered wire. One end of such a wire, half a mile long, was attached to a small buoy, which acted as a kind of float to the end, keeping the wire suspended near the surface of the water as it was paid out while the launch slowly steamed ahead against the tide. Such a wire was paid out and picked up in several positions between the primary circuit and the islands.

The apparatus used on shore was a 2-h.p. portable Marshall's engine, working a Pike and Harris's alternator, sending 192 complete alternations per second of any desirable strength up to a maximum of 15 amperes. These alternating currents were broken up into Morse signals by a suitable key. The signals received on the secondary circuits were read on a pair of telephones—the same instruments being used for all the experiments.

The object of the experiments was not only to test the practicability of signalling between the shore and the lighthouse, but to differentiate the effects due to earth conduction from those due to electromagnetic induction, and to determine the effects in water.

I have already alluded to the way in which the lines of current-flow were mapped out. It was possible to trace without any difficulty the region where they ceased to be perceptible as earth currents and where they commenced to be solely due to electromagnetic waves. This was found by allowing the paid-out cables, suspended near the surface of the water, to sink. Near the shore, no difference was perceptible whether the cable was near the surface or lying on the bottom, but a point was reached just over a mile away where all sounds ceased as the cable sank, but were recovered again when the cable came to the surface.

The total absence of sound in the submerged cable rather surprised me, and it leads to the conclusion, either that the electromagnetic waves of energy are dissipated in the sea water, which is a conductor, or else that they are reflected away from the surface of the water like rays of light.

Experiments on the Conway estuary showing the relative transparency of air and water to these electromagnetic waves, tend to support the latter deduction, for if much waste of energy took place in the water, the difference would be more marked. As it is, we have ample evidence that the electromagnetic waves are transmitted to considerable distances through water, though how far remains to be found.

There was no difficulty in communicating between the shore and Flat Holm. Messages were read. Mr. Gavey, who was making the experiment on the island, wrote me: "There was then somewhat a lengthened pause, due to a slight derangement of the machinery on the mainland, but at 2 p.m. I heard clearly and distinctly the following: 'Here Haskayne' (one of his assistants) 'with a message

from Mr. Preece for Mr. Gavey.'" I was in London that day. "Then followed the announcement of the sad and sudden death of Mr Graves, which cast a gloom over the success of the experiment. It seemed an extraordinary fact that the first readable message transmitted for such a distance by such means should announce the death of the head of the Technical Department."

The distance between the two places was 3·1 miles. The attempt to speak between Lavernock and Steep Holm was not so successful. The distance was 5·35 miles, but though signals were perceptible, conversation was impossible. There was distinct evidence of sound, but it was impossible to differentiate the sounds into Morse signals. We were just on the limit of audibility, and we were using our maximum power. If either line had been longer, or the

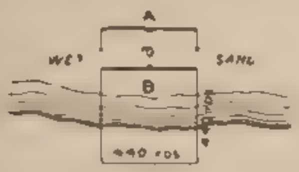

FIG. 10.

primary current stronger, we should have spoken as was done at Flat Holme.

The fact indicated by the formula for parallel wires that the limiting distance increases directly with the square of the length of the circuits, has a very important bearing on the practical results of these experiments, for it shows that if we can make the length of the two lines long enough, it would be easy to communicate across a river or a channel.

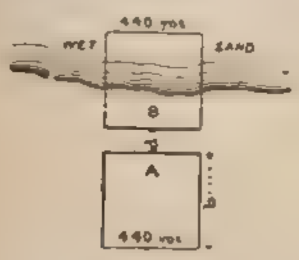

FIG. 11.

Of course, as previously pointed out, the formula does not take into account the effects of the reverse magnetic waves generated by the return current through the earth, and at present no data exist on which a satisfactory calculation can be based; but, for example, there is little doubt that two wires 10 miles long would signal through a distance of 10 miles with ease.

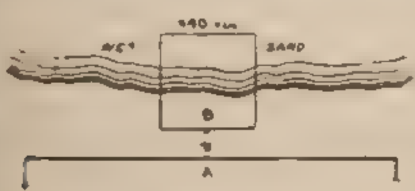

FIG. 12.

Although communication across space has thus been proved to be practical in certain conditions, those conditions do not exist in the cases of isolated lighthouses and lightships, cases which it was specially desired to provide for. The length of the secondary must be considerable, and for good effects, at least equal to the distance separating the two conductors. Moreover, the apparatus to be used on each circuit is cumbrous and costly, and it may be more economical to lay an ordinary submarine cable.

Still, communication is possible even between England and France, across the Channel, and it may happen that between islands where the channels are rough and rugged, the bottom rocky, and the tides fierce, the system may be financially possible. It is, however, in time of war that it may become useful. It is possible to communicate with a beleagured city either from the sea or on the land, or between armies separated by rivers, or even by enemies.

A use to which these electromagnetic disturbances can be applied is to indicate to ships their contiguity to lighthouses and land-falls. Experiments are being made in this direction by Mr Stevenson, of the Northern Lights Commission, on the coast of Scotland, but no results have yet been published. He proposes to submerge a cable on a given fathom line through which special automatic distinguishing signals are being sent, so that a ship approaching or crossing this line can pick up these signals on board and learn her true position.

I have also pointed out that as these waves are transmitted by the ether they are independent of day or night, of fog or snow or rain, and, therefore, if by any means a lighthouse can flash its indicating signals by electromagnetic disturbances through space, ships could find out their position in spite of darkness and of weather. Fog would lose one of its terrors, and electricity become a great life-saving agency.

APPENDIX.

I. EXPERIMENTS TO DETERMINE THE ELECTROMAGNETIC INDUCTION, BOTH IN WATER AND AIR, BETWEEN A RECTANGLE AND A FINITE LINE OF LENGTH EQUAL TO THE FACE OF THE RECTANGLE.

Currents were sent through the rectilinear circuit, A, by means of a suitable key, and the induced effect on the rectangle was observed on a carefully-adjusted reflecting galvanometer.

EXPERIMENT WITH CONDUCTORS COVERED WITH SEA-WATER (see Fig. 10).

d yds	Relative values of d.	Current through A (amps.).	Discharge deflection from B.	Equivalent in micro-coulombs.	Remarks.
100	1	2·00	16	·024	18ft. water over A
200	2	2·00	8	·012	—
300	3	2·00	5¼	·008	Constant—1·5 v.
400	4	2·00	4	·006	½mf. = 330
800	8	2·00	2	·003	—

EXPERIMENT WITH CONDUCTORS IN AIR.

d yds	Relative values of d.	Current through A (amps.).	Discharge deflection from B.	Equivalent in micro-coulombs.	Remarks.
100	1	2·00	17	·026	Low water.
200	2	2·00	8½	·013	—
300	3	2·00	5½	·008	—
400	4	2·00	4	·006	—
800	8	2·00	1½	·0023	—

II. EXPERIMENTS TO DETERMINE THE ELECTROMAGNETIC INDUCTION BETWEEN TWO RECTANGLES OF EQUAL DIMENSIONS (see Fig. 11).

l.	d.	Relative values of a.	Current through A (amps.).	Discharge deflection from B.	Equivalent in micro-coulombs.	Variation of deflection by formula $\frac{40}{\sqrt{d}}$	Remarks.
yds.	yds.						When current
440	8	1	2	40	·059	40·0	was reduced
,,	16	2	,,	28½	·042	28·3	to 1 ampere
,,	24	3	,,	23	·034	23·1	the induced
,,	32	4	,,	19½	·029	20·0	discharge
,,	64	8	,,	11½	·017	14·1	was halved.
,,	96	12	,,	8	·012	11·5	Constant—
,,	192	24	,,	4½	·007	8	1·46 v.
							½mf. = 330.

III. EXPERIMENT WITH A RECTILINEAR WIRE FOUR TIMES THE LENGTH OF THE FACE OF THE RECTANGLE (see Fig. 12).

d.	Current through A (amps.)	Discharge deflection from B.	Equivalent in micro coulombs.
192	2	20	·030

Accumulators in Paris.—The shareholders in the Société des Accumulateurs Electrique (Faure-Sellon-Volckmar) have agreed to a dissolution of the company, and have authorised the directors to transfer the assets to the Societe pour le Travail Electrique des Metaux.

THE

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CONTENTS.

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TELEPHONES.

The Postmaster-General at present occupies an anomalous position in respect to the legacy he inherited from the late Government—the Telegraph Act, 1892, on the one hand and the great telephone monopoly on the other. Sir James Ferguson was persuaded by the New Telephone Company to countenance and ultimately guide to completion a scheme devised by that company for the confusion of their opponent, the National. Being new competitors in the field, they saw the danger of isolation in certain urban districts, and appreciated the difficulties and delays attendant upon the creation of a rival system of trunk lines. They therefore convinced the Post Office officials of the expediency of purchasing the National trunks, whether the National liked it or not, and allowing New subscribers to use them on an equal footing with the rest. The New Company had likewise made an interesting arrangement whereby the City of London Electric Light Company had spent some £60,000 of their shareholders' money in laying tubes not required for the electric light, but designed for the use of the New Telephone Company if the necessary permission could be got from the powers that be. The expediency was therefore clear of obtaining an Act to enable electric light companies to lay tubes for telephone purposes. This, too, the late Postmaster agreed to, and the Bill in due time became an Act, notwithstanding the opposition of the National. So far all went well. The National had the worst of the game at all points, and having the sense to know it, their tactics changed. They sailed into the enemy's camp radiant in smiles, admiration, and congratulations, and obligingly offered to subscribe two-thirds of their rival's capital in return for a less than one-half representation on the Board. The bait took, and the rest is known. For any useful purpose the New has disappeared. But the Telegraphs Act remains, and the Postmaster's dilemma is in this wise.

Under the Act he has already spent many thousands of pounds in erecting new trunk lines. Belfast he has connected to Glasgow, and it is understood that a great north and south line from Scotland to London *viâ* Yorkshire and Lancashire is far advanced towards completion. But where are his customers to come from unless he makes an agreement with the National to switch their local subscribers on to the Post Office trunks? The prospective New Company's exchanges have disappeared, and he is left with his own insignificant exchanges at Newcastle, Leicester, and Cardiff, together with those of the National practically everywhere. And granting licenses to corporations will not help much. Suppose Glasgow gets a license and opens an exchange, without an agreement with the National neither the Post Office nor the National trunks would be available to the Glasgow Corporation subscribers, for the Post Office trunks have no exchanges at their other ends, while the National Company would refuse to allow theirs to be used. So the Postmaster sees the necessity of an agreement with the National, while that com-

pany is naturally taking advantage of its strong position to exact terms of which the public would possibly not approve if they came to be published. Consequently neither Mr. Morley nor the National are conceivably anxious for the agreement to be laid before the House until after signature, and Mr. Morley's apparent reluctance to bring the agreement forward has been commented on by several of our contemporaries. Fate has placed in the hands of the National directors a tomahawk originally fashioned for their destruction, and they would be foolish, from their point of view, if they failed to use it. But the position is most unsatisfactory for the telephone users. High rates and bad service will probably still be the rule, and the monopoly more grinding than ever.

ANALYSIS OF BOARD OF TRADE RETURNS.

In the early days of these returns we had some correspondence with the Board of Trade asking if the Department was likely to analyse and tabulate the returns. The Department did not do so, but subsequently a contemporary very pluckily made an analysis. We have been asked again and again to undertake the analysis of all the returns, and in this issue put forward a suggested form of such analysis. We have always held the opinion that too little attention was paid to the percentage of loss. Many companies refuse point-blank to give the figures necessary to show this percentage, and it may be taken without a grain of hesitation that in all cases where such figures are not given they are withheld because their publication would be damaging to the concern. We incline to the opinion that the percentage of loss will tell us far more as to the economy of design in distribution than any other figure or set of figures. Whether it will tell in favour of high pressure or low pressure we do not know, but most emphatically we deny that estimated losses have the same value as ascertained losses. In the production, or rather in the distribution of gas, losses are acknowledged, and every effort is made to reduce such losses. In electrical work it is possible to estimate the necessary loss, and the nearer the producer approaches to the theoretic figures the nearer his distribution comes towards perfection. Some companies give details as to losses in batteries and in mains with the losses unaccounted for, and it is really the smallness of such unaccounted for losses that in a measure determines the excellence of distribution, especially when the systems adopted are similar. The check upon our analysis is that the sum of the items should approximately equal the cost per unit, as obtained by taking the total cost as shown by the revenue account and dividing that amount by the number of units sold. If this test, which we venture to think is the correct one, is applied to the analyses hitherto published, it will be found that discrepancies exist. These may be accounted for in various ways. For example, rightly or wrongly, we place depreciation among the cost items, and do not consider that it can justly be otherwise placed. Railways do not depreciate, but keep their concerns efficient at the cost of revenue. Thus wear and tear is annually replaced and efficiency secured. In electrical matters wear and tear is not annually replaced, except by depreciation, which is merely another way of doing it. Insurance, again, approaches both the character of rent or tax as well as of depreciation. We put it along with rent and tax. It is by differently distributing such items that discrepancies may be found in the distributed items, but, unfortunately, differences will be found in the totals, and this is the main reason for our action. The error of a tenth of a penny may not seem much, but when the error has to be multiplied by hundreds of thousands the total sum is considerable. In fact, the tenth of a penny or even less will make all the difference between a large profit or a large loss. While, therefore, we make no claim to infallibility in the manipulation of figures, we do claim that it is important to know the actual cost per unit sold, and this is easily obtained when the total cost and the number of units sold is known. The amounts of the various items that make up this total are also worthy of great consideration. The variations in these show where waste and economy prevail, also where the apparatus and machinery are superior in design, make, or usage. What is the reason that the coal bill in one station is a farthing or a halfpenny per unit more or less than at another station within the same or a similar district, except that the boilers and engines at the one are more or less economical than at the other. It is not our intention at the present to draw inferences; we are seeking advice as to what information to give and how to give it.

ARMATURE PROPORTIONS.

BY F. M. WEYMOUTH.

A question on dynamo design that may often occur, especially to a beginner, has reference to the best proportions of length to diameter in an armature. It is hence the object of the following remarks to bring forward some of the considerations that bear on this subject. Assistance may thus, we would hope, be afforded to such as to whom this question may have had something of the nature of an unsolved problem.

Among the items demanding attention, the price of copper is of importance. If this metal is low in the market, it will pay to put a greater amount of it into a machine than when the price is high. Moreover, it is questionable whether much true economy would be attained by buying up a quantity of given sections of copper to lay in stock, even should the opportunity offer of obtaining it at a low figure. Copper at the best is expensive, and a large quantity might thus be laid in which for a time would be of no use, thus representing capital without interest. Hence it is usually bought as it is wanted, and ruling prices have to be watched.

To consider first, then, the application of these remarks relating to copper, we find the point to be aimed at is the attainment of a maximum amount of magnetic induction in the magnets, and of E.M.F. in the armature coils, with a minimum of copper. As is well known, the smallest periphery that can enclose any given area is a circle. Hence the copper is used most economically when the coils are circular. This is exemplified in the Thomson-Houston machine, wherein the armature is spherical and the magnets cylindrical, though as to the former, this only holds good in respect of the exterior coils, as the inner coils, owing to the overlay at the ends, become less circular.

common, however, among other makers, to have cylindrical magnet cores. Nevertheless, perhaps the majority adopt magnets of rectangular cross-section. The armatures are likewise rectangular on their longitudinal, which is also their effective, section. Now, the rectangular area having the shortest periphery is the square. The more oblong any given area is, the greater will be its periphery. Thus, an area of, say, nine square inches may be enclosed in a square of 3in. × 3in. having a periphery of 3in. × 4 = 12in. If this area be shaped 6in. × 1½in., its sides becoming thus as 4 to 1, its periphery will be 15in., or 25 per cent. more than when square. This would thus point to the advisability of adopting a short, broad machine, with magnets of square cross-section, or nearly so, and an armature having a core one diameter in length; and with this, of further obtaining the option of making the magnet cores cylindrical and the coils circular, and so to dispose the copper still more economically.

But a point, on the other hand, immediately rises here which destroys the harmony with which this question is apparently settled. It has only to be mentioned to be at once recognised that, with regard to the armature, it is the parallel inductors alone on the circumference that generate

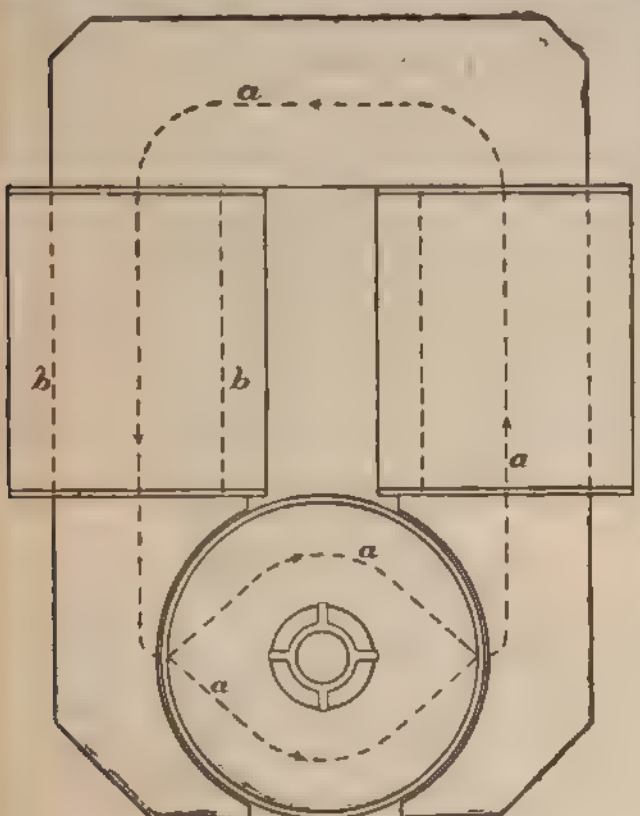


FIG. 1.

current, while the copper connections across the ends have no value in this respect. Hence, it will be seen that to apply the copper most effectively, and so economically, in this case the armature length should be much greater than the diameter, and thus as large as possible a proportion of the copper be employed cutting lines of force and generating E.M.F. It will therefore be seen that so far from the question being one of an easy harmonious settlement, we are at the outset confronted with conflicting requirements, the former needing that the armature should be of square longitudinal section, and the latter that its length should be as great as possible in proportion to its diameter. But of this we shall find more.

Now, as comparisons are often made clearer by supposing an extreme case in one direction or the other, we may adopt that method here. Thus, we may compare the case of a machine having an armature core one diameter in length, with the case of one having the armature core of the same effective longitudinal sectional area, but four diameters in length. These we illustrate in Figs. 1 and 2 herewith. In the former the armature core is, say, 24in. in both length and diameter, while in the latter it is 12in. diameter and 48in. long. The central hole in the short armature is, moreover, twice the bore of that in the long one, so that the same proportion of the diameter is removed in each case, and the actual total effective longitudinal sectional area of the core proper is the same in both, though of different outline. The circumference of the short core will be about 75in., and of the long core about 37·5in. We may use this comparison looking at the subject from all points; and we, moreover, suppose the same output from each—at least, to be intended. It will now at once be obvious that a much larger number of turns can be put on the circumference of the short armature than on the long one, unless on the latter they be laid in two layers. This arrangement, however, would cause the air-gap, or distance between the inner surfaces of the pole-pieces and the core, to be nearly (the clearance not being doubled) twice as great in the case of the long core as the short one. As these air-gaps are the most formidable source of reluctance to the whole magnetic circuit, doubling them would make a serious difference, and our comparison hence would not perhaps be reasonable. The difficulty may, however, be obviated by giving the long armature twice the speed of the other, and so do with only half the number of turns in its winding. This will thus render only one layer of conductors necessary on its circumference; while its increased speed would but be agreeable with the natural law that the limits of speed are greater in the case of small than of large diameters. The peripheral velocity also will now be the same in both.

Having thus assumed comparative cases, we may consider the copper, and our remarks here will apply more especially to drum armatures. Let us suppose that on each

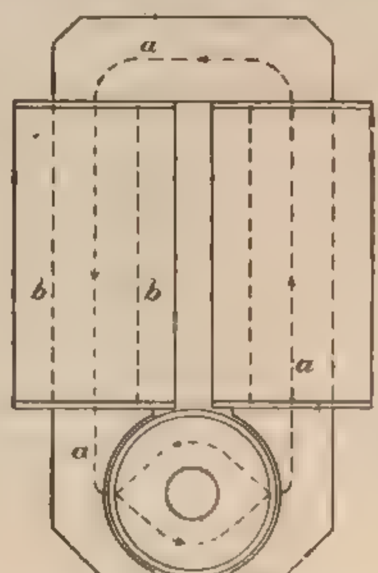


FIG. 2.

armature the layer of copper conductors is ½in. thick, while the insulation, being of the same proportion in both, may be disregarded. Now, with the short core, rather more than half the copper, through its not running for constructional reasons in direct lines across the ends, is idle. With the long armature, for the same reasons, we may say that rather more than a quarter of the copper used at the ends, is also idle. We may now look at the totals of copper. In the case of the short core, the circumferential surface is 75in. × 24in. = 1,800 square inches. With ½in. layer of conductors we get 1,800 × ·5 = 900 cubic inches of copper. To this add rather more than as much again for the end connections, as above explained, and we get, say, 1,000 + 900 = 1,900 cubic inches total of copper for the short armature. With the long armature, the circumferential surface being 48 × 37·5 = 1,800 square inches, or the same as the other, we have also 900 cubic inches for the parallel conductors. But here we need add, as stated, rather more than a quarter only for the end connections. We thus get, say, 300 + 900 = 1,200 cubic inches total of copper on the long armature—that is, 700 less than on the short armature. In other words, the square armature has

rather over 58 per cent. more copper than the long armature for the same output.

The field coils have now to be considered. In the case of the short machine, as shown in Fig. 1, the section at *b b* is 24in. × 13in. With the long machine this is 48in. × 6½in. The periphery of the former is thus 74in., and of the later 109in. But allowing for, say, 2½in. thickness of copper, the mean periphery of the coils will be 84in. and 119in. respectively. There will thus be 35in. (in mean peripheral length) more copper in one coil of the long machine than in one coil of the short machine; or, in other words, the coils of the former will contain about 41½ per cent. more copper than those of the latter. The mean periphery of one corresponding coil on a cylindrical magnet would be 75in., or 44in. less than with the long machine, which gives about 58½ per cent. more copper in the coils of the long machine. There will thus be either about 41½ or 58½ per cent. more copper in the magnet coils of the long machine than the short one, according as to whether the limbs of the latter are rectangular or circular in section. Hence, whereas in the field coils of the short machine we find a saving of 41½ or 58½ per cent. as compared with those of the long machine, yet in the armature of the short machine we have found a loss of about 58 per cent. in copper as compared with the armature of the long machine.

But our ½in. thickness for the armature coils is empirical; and so also is the 2½in. for the magnet coils, and the latter may be any thickness up to 3in. or more. It may thus now be observed that the absolute value of the 41½ or 58½ per cent. saving in the field coils of the one (both limbs being considered) may greatly exceed the absolute value of the 58 per cent. saving in the armature of the other machine. The proportional monetary value of the magnet coil percentages would be still further increased if they were shunt wound, owing to the much greater cost of fine insulated wire as compared with thick coils. Hence, to arrive at the greatest economy a compromise must be effected, and the machine so designed as a whole that the absolute value of the loss in the one direction should be on a par with the gain in the other. It thus follows that with any given depth and thickness of field coils, as the absolute value of the percentage gained by the long armature must vary with the thickness of its winding, a greater length of armature will be justified when heavily wound than when only lightly wound for small currents. In the latter case, indeed, it becomes very plain, especially in a machine with shunt-wound magnets, economy in copper is to be found in the direction of a short armature and cylindrical magnet cores.

Now it will be noted that in our remarks so far we have spoken of the same *intended* output from each machine only. We have assumed field coils of the same magnetomotive force in each machine. With the armatures as described in connection with Figs. 1 and 2, it might at least seem that the output would be the same in both cases. But some points yet remain for consideration, however, that will affect this conclusion. We allude to the comparative length, of magnetic circuit which we mentioned near the commencement of our remarks. It will be observed in Figs. 1 and 2 how that the mean path of the magnetic circuit in each machine is represented by a dotted line, *a a*, divided in two through the armature. Now, in Fig. 1, this measures in total length round about 140in., while in Fig. 2 it is about 95in., making a difference of nearly 50 per cent. In both cases the air-gap is the same. Now, perhaps, about four-fifths of the magnet coils may be employed solely in overcoming the resistance offered by the air-gaps to the magneto-motive force they exercise. Hence one-fifth only is concerned with forcing lines of magnetic induction through the iron of the circuit. Now, the reluctance of the iron varies as its length, and inversely as its cross-sectional area. The cross-sectional areas being the same in the cases we are supposing, length alone need be considered; and it follows that the reluctance in the iron circuit in the short machine, Fig. 1, is nearly 50 per cent. more than in the long machine, Fig. 2. Hence there will need to be added, on this count, to the magnet coils of the short machine 50 per cent. of one-fifth of the ampere-turns, as compared with those on the long machine, or one-tenth more, to get the same strength of field. With cylindrical magnets, of which the cores would be 20in. in diameter to be of the same cross-sectional area, the machine would become still broader, and the magnetic circuit becoming yet ·ger, a greater proportion than one-tenth would need to be added to overcome the extra reluctance of the iron circuit.

On the other hand, the leakage and waste field in the long machine must be considerably more than in the short one. Leakage, it may doubtless be said, can only take place as there is opportunity. Now this, as is well known, is especially afforded by the close proximity of a pole of opposite polarity, and by an extended protruding polar periphery. This opportunity, as here described, is precisely what is offered much more in the long machine than the short one; for on the latter point it will be remembered that lines of magnetic induction have a tendency to crowd about and out of a projecting point or edge, especially if protruding in their natural path, a greater facility of exudation being thereby afforded. In other words, it is much easier for the lines, though compressed into greater density, to flow out through a ridge (more or less) projecting in their course than from a flat surface that recedes.

In our long machine, Fig. 2, it may be observed, first, that the pole-pieces are much nearer each other than in the short machine; and, secondly, that the horns of the former, in length parallel with the shaft, are twice as long as those of the latter. The sectional areas in plan of the pole-pieces are very narrow; but these areas are the same in total amount as the corresponding sectional areas in the short machine. Being thus altogether nearer, and also more extended in direction parallel with the shaft in the case of the long machine than in the short machine, it is obvious that of the total amount of magnetic induction resulting from the magnet coils, more will be wasted, or pass as free magnetism through the air from one pole-piece to the other, in the former than in the latter. Mathematical treatment of this subject may be found in Prof. Silvanus P. Thompson's "Dynamo-Electric Machinery."

Our purpose, however, is sufficiently served in the fact of the greater waste field with the long machine being established; for now it will be seen, that to make good this loss, additional ampere-turns must be put on the magnet coils of the long machine. Hence, whereas we have but just discovered that some of these turns might be *reduced* on the long machine, because of its shorter magnetic circuit, we now find that, more or less, they will need to be put back again to cover the leakage. This forms, in fact, another case of conflicting requirements.

A remaining point that may be noted concerns the core. Calculation will show that the short core, although of the same longitudinal sectional area, will yet have twice the weight of the long core. Hence it may be taken, roughly, that the short core will cost twice as much as the long core, which forms another item for consideration.

We thus find, in conclusion, that inasmuch as the two questions of the length of magnetic circuit and the waste field have a neutralising or cancelling effect on each other, attention may be reverted to the cost of the copper that may be used, and also of the iron discs. It would therefore appear that armatures of great length are most justified when wound for heavy currents. The great total amount of copper such as there would then be in their winding would render the saving due to the increased length and shortened diameter of greater proportional account, to which may be added the further saving (above alluded to) effected by the lesser total weight of charcoal iron core discs. While, especially if the machine were series wound, thus avoiding the expense of fine shunt winding, economy with the copper of the magnet coils becomes proportionally of less consequence, and a long rectangular section of magnet will not perhaps be so inadvisable.

Aix-la-Chapelle.—The Municipality has just granted permission to the Aix-la-Chapelle and Burtscheid Tramway Company to substitute electric traction for the horse cars now in service. The current will be provided by the local electricity works, and the system to be introduced is the overhead trolley method.

PATIN FLYWHEEL ALTERNATOR.

Direct-driven alternators have been familiar to electrical engineers in the Westinghouse and other plants, though apparently until lately a preference has been shown in English practice for rope-driven alternators. We illustrate this week a direct-driven alternator of French construction of the Ferranti type—the Patin "flywheel alternator," connected direct with a horizontal engine of the Blondel type with Corliss valves, made by E. Boyer. The Corliss detents are placed two and two beneath the cylinder at each end, and give rapid opening and shutting at all positions of the piston from 0 admission up to maximum admission of 75 per cent. In the variable detent of the Blondel, a single excentric would only vary the admission from 0 to 35 *per cent.,* but with two excentrics the admissions can be varied to 75 per cent.; further, for ordinary admissions around 20 per cent. the closing of the parts is extremely rapid—[illegible]th to $\frac{1}{30}$th of a second—as the excentric radius is then vertical and the greatest speed is at that point.

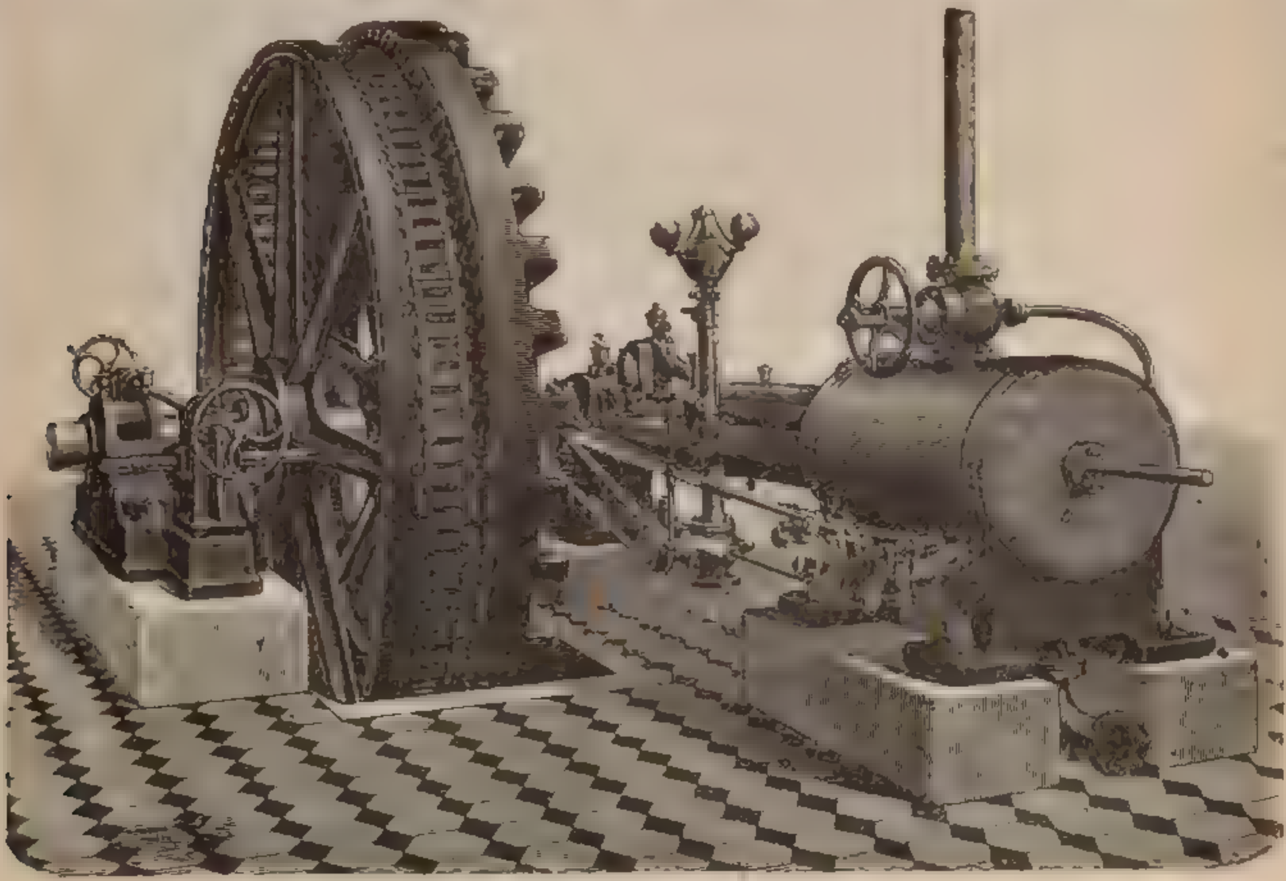


Fig. 1.—Patin Flywheel Alternator.

The most interesting part of the engine is the flywheel, which constitutes, in effect, the field magnets of the alternator on the system of M. O. Patin, which has been perfected by long experience.

Alternating machines, if direct driven, usually require a relatively high speed, which means a higher steam consumption, or else necessitate the use of gearing if slow-speed engines of greater efficiency are employed. The flywheel alternator alone avoids both disadvantages. As the field magnet forms also the rim of the flywheel, foundations for the dynamo are avoided, the oiling expenses are reduced, space is saved, and the superintendence is rendered easier.

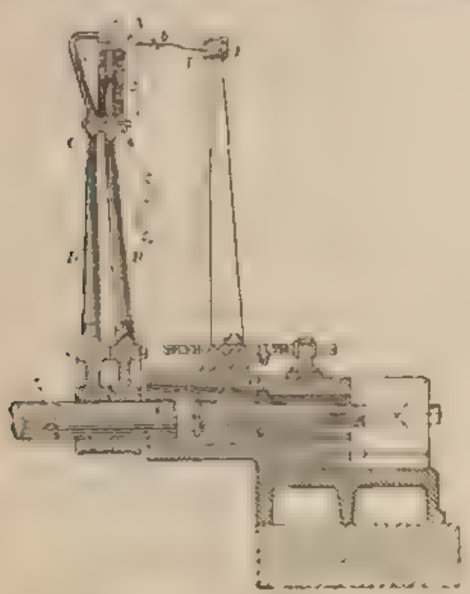


Fig. 2.—Patin Flywheel Alternator—Details.

Fig. 3.—Induction Poles.

In the illustration the armature is shown slightly drawn back from the fields in order to distinguish the two parts

of the alternator. The armature, being fixed, is not acted upon by any mechanical force other than the magnetism of the fields, and is not liable to deterioration. High tension collectors are also avoided, and there are no brushes, the mains being, of course, connected direct to the terminals.

For large installations the cost of generating energy is most important, and engines of slow speed and high efficiency are desirable. M. Patin therefore uses for his alternators speeds of 60 to 100 revolutions per minute.

The alternator comprises thus:

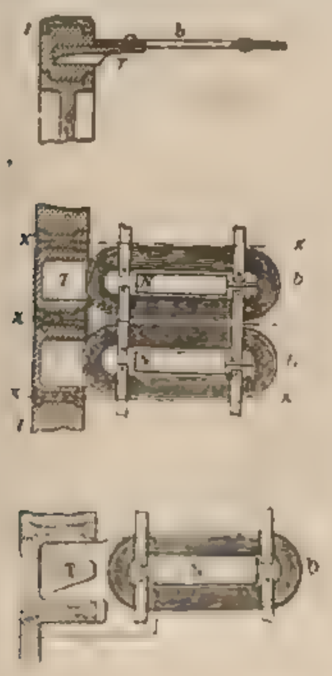
(1) The flywheel field magnets, fastened to the crankshaft of the engine, serving the double purpose of engine flywheel and dynamo fields.

(2) A fixed armature, which, however, can be displaced along the axle in a supporting socket so as to separate it from the fields for inspection of the coils.

(3) A supporting socket of the armature, fixed upon the foundation of the outside bearing of the crankshaft, and forming part of the same bearing.

(4) Various accessories: such as shifting screw of armature, collecting rings for exciting current, etc.

(5) An exciting dynamo.



FIGS. 4, 5, and 6.—Details of Armature Coils.

Flywheel Fields.—The field magnets comprise two distinct parts: first, an inside crown, A (Fig. 2), in one or two pieces of cast iron, connected to the hub by arms, B, and carrying on its periphery soft iron poles, P (Fig. 3), forming the internal part of the magnetic field. Each of the poles, P, carries an extension, E, fixed by bolt and screw, which can be taken off to allow the field-magnet coil, *y*, to be placed around the core. The number of the poles, P, is variable for each size of dynamo and according to the speed of rotation, so as to obtain a constant periodicity for all machines; and, second, a crown of cast iron, A, carrying on its external face projections forming the external poles, P^1, equal in number to the internal poles, P. The exterior crown is connected solidly to the interior crown by a cast-iron ring and radial arms, C, solidly bolted to the internal crown, A. The ring, C, is connected by arms, B^1, to a hub bolted to that of the internal crown. The assembling of these parts is arranged so as to leave between the poles, P and P^1, a regular and sufficient space for the coils of the armature.

Armature.—The armature is composed of a cast-iron crown, I, Figs. 2-7, with equidistant cavities; arms connect it with the bored hub, M, rubbing with slight friction on a socket, D, which act as support and guide. In each of the cavities of the armature crown is sealed the end of a bronze plate, serving as core to the coil. The sealing is done with a material which completely insulates it from the crown. Each armature coil, *b*, is independent of the others, and is easily replaced: it consists of a core, N, of bronze, laminated to avoid eddy currents; on this core are wound a strip of copper and a strip of insulating fibre placed together. The coil thus formed is carefully varnished to a circular surface with gum-lac. Each bronze carrier carries two coils, bolted thereto.

The set of carriers, after sealing, is turned up in the lathe, the cores of the coils being centred and exactly fitted to measure, presenting a perfectly centred cylinder between the field-pole extensions, with a play of a few milimetres. The projecting parts of the coils are kept rigid by metallic hoops insulated from the coils.

On the upper part of the armature are fixed two terminals for taking off the current.

FIG. 7.—Armature.

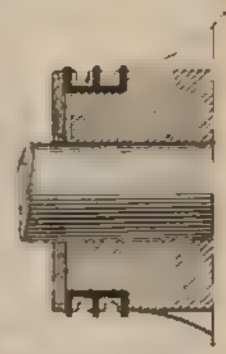


FIG. 8.—Collector Rings.

Supporting Socket.—The armature is fastened on a strong supporting socket of cast iron, D (Fig. 2), through the centre of which passes the engine crankshaft; it forms one with the base plate of the outer bearing, bolted solidly to the foundation. Longitudinal movement is prevented during working by a linch-pin arrangement.

Withdrawal Gear.—To inspect or replace coils, the armature is withdrawn from the fields by a simple arrangement of threaded rod, M, with two collars, turning freely in a bearing fixed to the supporting socket, Fig. 2, working in a screwed slot in the hub of the armature. A ratche lever serves to work it; and the hub of the armature slide to and fro as desired along the supporting socket. The length of the fixed wedge of the supporting socket is limited, so as to allow the armature to turn at will on a socket when withdrawn from the field magnets.

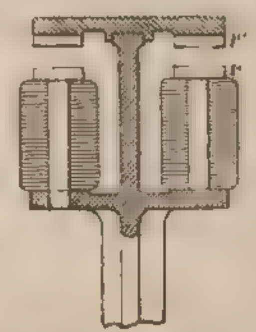


FIG. 9.—Alternator with Double Field Magnets.

Exciter Rings.—The exciting current, from a separate exciter or commutated coils, as the case may be, is led into the fields by two bronze rings fixed on the flywheel hub, insulated by fibre discs, Fig. 8.

The above comprise the various parts of the Patin flywheel alternator, as constructed from 50 h.p. to 300 h.p.; above this the flywheel alternator carries a double magnetic field, Fig. 9, with two armatures on each side.

These alternators, adds the *Revue Industrielle* (from which we take the description and illustrations), are easily put together and attended to; their working is absolutely regular, whatever the variation of load, as the armature does not contain a particle of iron. For powers less than 50 h.p. the alternators run at speeds allowing direct coupling to turbines or high-speed engines.

(To be continued.)

WORLD'S FAIR ELECTRICAL PLANT.*

BY R. H. PIERCE.

Of all the cities that have ever been built, there has never been one in which electricity has played such an important *rôle* as in the White City. The present exposition is the first international exposition in which electricity has been recognised as one of the great departments, and no previous electrical exhibition has equalled the electrical exhibit of the World's Columbian Exposition. Volumes have already been written upon the various electrical exhibits, and all that will be attempted in this brief paper is a description of the great plant which furnishes the electrical service of the exposition. The electrical plant comprises a local telephone exchange, complete systems of police signal and fire-alarm service, and the plant for furnishing electric power and light.

Telephones.—The telephone exchange is a regular exchange of the Bell system. It comprises at present 130 telephones. It supplies service for the offices of the officials, the engineers, and superintendents. It forms an adjunct to the fire-alarm service, and connects the head quarters of the police department, the department of admissions, and of the secret service with all gates and with all portions of the grounds. It contains no points of novelty, but is an interesting exhibit of a great private exchange. It is installed with complete metallic circuits of double and twisted rubber-covered conductors. The circuits comprise 150 miles of No. 18 B. & S. wire, and the service is practically unaffected by the proximity of the immense number of circuits carrying currents, both direct and alternating, and all degrees of current strength.

Police and Fire Signals.—The police signal and fire-alarm systems comprise 137 fire-alarm boxes of the Gamewell Fire Alarm Telegraph Company, and 137 police boxes, and 50 watchmen's patrol boxes of the Police Telephone and Signal Company. These systems are two well known to need even comment, and make the service uniform with that of the city of Chicago, to which it is connected. The boxes are distributed about the grounds and buildings in pairs, each fire-alarm box having a corresponding police box. The number of boxes is estimated to be sufficient for protecting a city of 150,000 inhabitants, and its installation consumed 80 miles of No. 14 B & S rubber-covered wires. The watchmen's patrol boxes are located under the floors of the main buildings, and enable the guard to send in an alarm direct to headquarters without even the loss of time required to reach the nearest fire or patrol box.

Light and Power Plant.—The portion of the plant which especially commends itself to the interest of both the engineer and the architect is the plant for electric lighting and electrical transmission of power. All the electrical machinery for furnishing light and power is located in Machinery Hall, so that the power plant in Machinery Hall is a great central station. I say "central station," but, in fact, the plant is divided, as far as operation is concerned, into nine distinct central stations, each of which, under normal working conditions, is entirely independent. The plant comprises 98 direct-current series arc dynamos, having a total capacity of 5,230 lamps of 2,000 nominal candle power each; 14 alternating-current incandescent dynamos, having a total capacity of 128,000 lamps of 16 c.p.; one direct-current incandescent dynamo, having a total capacity of 800 kilowatts, and 20 direct-current power generators, having a combined capacity of 2,936 kilowatts, or 3,935 e.h.p. In addition to these there, are also four direct current generators having a total capacity of 600 kilowatts, or 804 e.h.p., which serve the double purpose of supplying current to operate the electric fountains and to charge the storage batteries for the electric launches. There are also one direct-current generator of 700 kilowatts, or 938 e.h.p., which operates both arc and incandescent lamps; and, finally, one direct-current generator of 180 kilowatts, and one of 45 kilowatts, a total of 225 kilowatts, or 300 e.h p., which supply the current for search-lights. The entire plant has a generating capacity of 14,916 kilowatts, or 19,989 e.h.p., so that it would require not less than 25,000 i.h.p. to operate all the dynamos to their full working load.

Circuits.—The circuits from all dynamos are carried under the floors of the power plant to the several switchboards, and thence under the floor to the gallery, which runs the entire length of the power plant, and under the aisle directly north of the plant. This gallery is for the greater part of its length 13ft. wide and 9ft. high, and is shut off from the rest of the basement on both sides by walls of expanded metal and cement. Along each side of the gallery is a row, and down through the centre are two rows of cast-iron uprights placed 30ft. apart. These uprights have sockets into which are driven oak cross-arms. These arms carry from four to six pins, and have, in all, sufficient pins and insulators for 280 wires, allowing but one wire to an insulator, but, by the use of a special two-wire insulator designed for this purpose, the capacity of the gallery is greatly increased. From this gallery, the circuits are carried out of Machinery Hall in the main subway and the duct trunk line. All the circuits feeding the east portion of the park are carried in an underground tunnel called the main subway.

Subway.—The main subway, as it passes under the east end of Machinery Hall going north, is a double tunnel, each half of which is constructed as follows: A series of frames are built of 3in. by 8in. timber, and are covered on the outsides, on the top and sides, with 2in. plank. On the inside the top and sides are covered with expanded metal and plaster, and the floor is formed of Portland cement. This forms a practically fireproof tunnel, 6ft. 6in. wide and 6ft. 5in. high. To the timbers on both sides of each tunnel are legged cast-iron uprights 30ft. apart. These uprights carry on each side of the subway 12 five-pin cross arms 2ft. 3in. long, so that one can walk in a 2ft. passage having on either side a regular underground pole line. Conductors are carried on double petticoat insulators, there being capacity in the entire subway for 250 insulators. Here, as in the gallery, many two-wire insulators are used. The subway is lighted by incandescent lamps and drained by hand pumps located at low points. When single insulators are used, all wires are rigidly separated and not less than 5in of air space is allowed. The main subway runs due north to Electricity Building, where the west half enters the building, and then branches, running to the Mines Building, and the east half makes a right-angled turn, running east to the bridge over the north canal. The circuits are then carried under the bridge, and on the east of the bridge the subway is continued to the south-west corner of Manufactures Building, whence, decreased in section, it runs north the entire length of the Manufactures Building, under the West Loggia. It then runs east to a point north of the centre of the Manufactures Building, thence north to the Government Building. Under the Government Building it is constructed with a covering of expanded metal and plaster, both inside and out, and from the Government Building it is continued to the Fisheries Building, where it ends.

Duct Trunk Lines.—The circuits feeding the west half of the park and Midway Plaisance, with the exception of the power circuits, are carried from the gallery under Machinery Hall to the north side of Machinery Hall in a conduit of 3in. and 4in. vitrified tile ducts. Thence the duct trunk line is continued by 30 ducts of pump log of 2½in. bore. Large manhole boxes, 30in. by 36in. are set every 150ft. This trunk line runs under the terminal tracks to the south-west corner of Transportation Annex, whence it runs parallel to the fence, to a point near the north end of the California State Building. From the main subway and duct trunk line, the circuits are distributed throughout the grounds in wooden ducts of 2½in. bore. These ducts form a network all over the park, and are intersected at angles and convenient points by manholes with cast-iron covers. There are in all about 100 miles of these ducts, and about 3,500 manholes. Thus all circuits are carried underground except those south of Machinery Hall and along fences. These are carried on poles, while the power and telephone circuits on the west side of the park are run under the structure of the elevated intramural railway.

(To be continued.)

* *Paper read before* the World's Congress of Architects, *Chicago, August 2, 1893.*

THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

LECTURE III.

THE MEASUREMENT OF ALTERNATING CURRENT POWER.

Having dealt in the preceding lectures with the subject of the measurement of alternating current strength and alternating current pressure, I propose to consider now the measurement of alternating current power.

When the current is flowing through a conductor it dissipates energy, and the rate at which this energy is dissipated is spoken of as the power taken up in that circuit. When a constant current is flowing through a conductor, if we measure the current in amperes and the difference of potential in volts, then the product of these two numbers gives us the power taken up in the circuit measured in watts. In this case two simple measurements gives the required rate of dissipation of energy in the conductor. If, however, we have to deal with an alternating current, in which the current strength is varying from instant to instant, according to a periodic law, and if likewise, the difference of potential between the ends of the circuit is varying in the same periodic manner, we cannot always obtain the measurement of the mean power taken up in the circuit, generally speaking, by taking the product of the √mean square amperes and √mean square volts. What we really require in this case is the mean value of the power taken up in the circuit. We can obtain the measurement of the mean power if we can measure at every instant the true value of the current strength and the difference of potential, supposing these instantaneous values of the current and pressure known at equidistant intervals taken throughout one complete

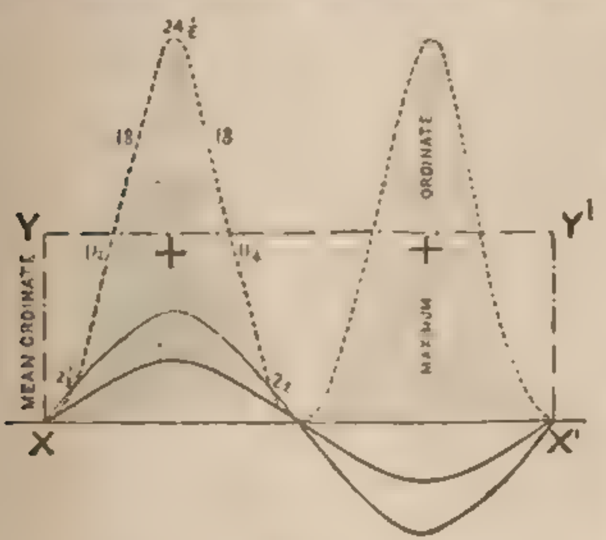


FIG. 1.

period: if we then multiply the instantaneous value of the current by the corresponding value of the pressure, or difference of potential, and multiply these together, we obtain a number representing the instantaneous value of the power, and if we imagine the period divided into a large number of equidistant intervals of time, and those products taken at every such instant, then the mean value of those products, taken throughout the period, would give us a close approximation to the mean value of the power being absorbed by that circuit.

We have seen in a previous lecture how it is possible to determine and describe curves representing the instantaneous values of the current and E.M.F. in the case of an alternating current circuit, but this in general is not a simple matter to do, and we have therefore to resort to other methods of obtaining the required result.

In dealing with the power taken up in alternating current circuits, there are two cases to be considered.

The first case is that in which the circuit is non-inductive. In that case, as before explained, the impedance of the circuit is the same as its resistance, numerically speaking. For such circuits the alternating current flowing in the circuit is in step as regard phase with the alternating potential difference between its extremities. When this is the case the power taken up in that circuit can very easily be measured. If we measure the √mean square value of the alternating current by means of any of the balances of dynamometers described in the first lecture, and if by means of any of the electrostatic or thermal voltmeters we measure the √mean square difference of potential between the ends of the circuit, and multiply these two mean square values together, we obtain the mean value of the power taken up in the circuit, and we arrive at the same result as if we had been able to measure separately the instantaneous values of the current and potential difference at numerous equidistant intervals throughout the phase, and taken the mean value of their products.

* Cantor lectures, delivered before the Society of Arts.

As an instance of this, it may be pointed out that an incandescent lamp may be treated as a practical non-inductive circuit. If this incandescent lamp is traversed by an alternating current, and we measure the current flowing through the lamp by means of, say, a Siemens dynamometer, the potential difference between the terminals of the lamp by means of, say, a Cardew voltmeter, and if we multiply the two scale readings of these instruments together, we obtain the mean value of the power measured in watts taken up in the lamp.

So far, then, all is quite simple, and in dealing with any circuit which we know or can prove to be practically non-inductive, we have no difficulty, by means of two instruments of the proper kind, in determining the real mean power taken up in the circuit. Our difficulties come in when we have to deal with circuits such as transformers, which, when not fully loaded, we know to be inductive. If in this case, we can determine the instantaneous values of the current and difference of potential between the ends of the circuit, then proceeding as above described, we can determine the mean value of the power taken up in the circuit. If, however, it is not convenient to do this we cannot proceed to measure the √mean square value of the current and E.M.F., and then multiply them together. Such a proceeding would lead to a considerable over-estimate of the real power taken up in the circuit. Without going into elaborate proof of this it may be simply sufficient to present the following figures:

In Fig. 1 are shown two simple harmonic curves in step with one another. The semi-period is divided into eight equidistant parts, and ordinates are erected at each point. The values of these ordinates for the two curves, which may be taken to represent periodic current and electromotive curves, are given below the diagram. By squaring each of the values of the ordinates, and taking the square root of the mean of the squares, we obtain for each curve a number which would represent the instrumental value obtained by an alternating current dynamometer or voltmeter. If we multiply together the simultaneous values of current and E.M.F., we obtain a number which represents the instantaneous

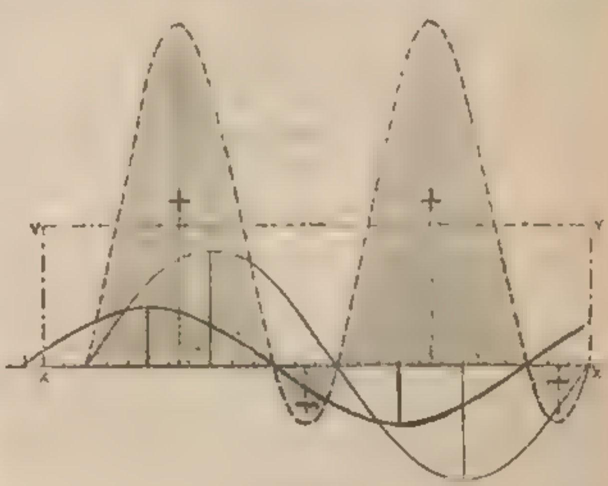


FIG. 2.

value of the power taken up in the circuit, and if we take the mean value of all these separate instantaneous values of the power, we obtain the same number as we do if we take the products of the square roots of the mean of the squares of the instantaneous values of the current and E.M.F. Hence we see that when the two simple harmonic curves are in step with one another, the product of the square root of the mean of the squares of the separate ordinates is equal to the mean value of the products of the corresponding ordinates.

In Fig. 2 are shown two periodic curves, which may be taken to represent a current and an E.M.F. curve, but one of which is displaced backwards relatively to the other. This is what happens in an inductive circuit where the periodic current always lags in phase behind the periodic E.M.F.

If we perform the same operations on the ordinates of these curves, we find that a product of the mean square values is in excess of the mean of the products. In other words, if in such circuit we measure the current by means of a dynamometer, and the potential difference between the ends by means of an alternating current voltmeter, the product of these two numbers gives us a number which is in excess of the true value of the mean power taken up in the circuit.

It is convenient to call the product of the √mean square amperes and the √mean square volts the apparent watts taken up by the circuit, and to call the true mean value of the power the true watts taken up by the circuit.

The ratio between the true watts and the apparent watts is called the power factor of the circuit. Thus, for instance, in the case of a transformer on open circuit, the transformer being of the closed magnetic circuit type, the power factor is about .7, in other words, the real power is only three quarters of the apparent power. In the case of a transformer of the open magnetic circuit type, the power factor may be as small as .1. Hence, you see that an enormous error in this case would be committed by taking the product of the instrumental readings as simply representing true mean power taken up in the circuit. We have, to

consider in what way this true mean power can be practically measured in the case of alternating-current circuits.

There are many methods by which this may be done. A large number of methods have been described which look very excellent on paper, but which do not in practice turn out so well. As I desire only to bring under your notice those methods which are capable of being practically employed, I shall pass over the theoretical methods, and turn at once to the description of those instruments which will enable us to measure practically the power taken up in the inductive circuits. The most practical, and by far the best, instrument to use for this purpose is the electro-dynamometer instrument. Consider a dynamometer, such as one of the Siemens dynamometer described to you in my first lecture. Let the fixed coil of this dynamometer be placed in series with the circuit in which we desire to measure the power being taken up. Let the movable circuit of the dynamometer consist only of a few turns of wire, and let this movable circuit have joined in series with it a non-inductive resistance, which may be formed either of coils or wire, or incandescent lamps. Let this movable circuit with its added resistance be placed as a shunt across the ends of the circuit in which it is required to measure the power, being joined up as shown in Fig. 3. Then when the alternating E.M.F. is applied to the circuit, the fixed coil of the dynamometer (now called a wattmeter) will be traversed by a periodic current identical with that passing through the inductive resistance. The movable coil of the wattmeter will be traversed by a current which will be in step as regards phase with the potential difference between the ends of the inductive circuit. When the dynamometer thus has its two circuits traversed by two currents, the force required to hold the movable circuit in its normal position against the electro-dynamic forces, is at any instant proportional to the product of these currents. If then the currents vary from instant to instant, and if the time of vibration of the movable coil is very long compared with the periodic time of the current, the mean value of the force required to hold the movable coil in its normal position with its axis at right angles to that of the fixed coil, will be proportional to the mean value of

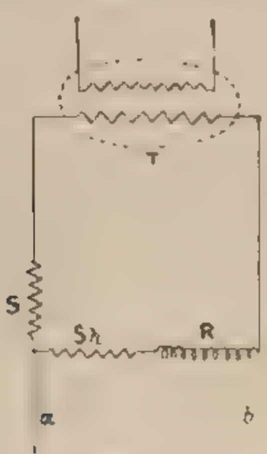


Fig. 3.

the products of the currents in the fixed and movable coils respectively—that is to say, will be proportional to the mean power being taken up in the inductive circuit. The force required to hold the movable coil in its normal position may be furnished by the torsion of a spring, and hence we can with such an instrument read off the mean power being taken up in the inductive circuit, provided that the wattmeter is already standardised. The best way to standardise the wattmeter is to apply the wattmeter to measure the power taken up in a known standard non-inductive circuit, and, at the same time, to measure the $\sqrt{\text{mean square}}$ value of the current flowing through this circuit and $\sqrt{\text{mean square}}$ value of the potential difference between its ends. In this way we apply the wattmeter to measure the known power being taken up in a non-inductive circuit, and we then obtain the constant of the instrument.

The conditions of success in the use of this wattmeter are as follows:

1. The current through the series coil of the instrument must have the same value as the current through the circuit to be measured, and the current through the shunt coil of the wattmeter must be exactly in step with the difference of potential between the ends of that shunt circuit; in other words, the shunt circuit must be strictly non-inductive. This can only be secured by winding the movable coil of the wattmeter with no very great number of turns.

On the other hand, we then have to face another difficulty when we employ such a wattmeter to measure the power taken up in the primary circuit of transformers at high pressure. In this case, in order to obtain the sufficient magnetic moment in the movable circuit of the wattmeter, we are obliged to pass a relatively large current through the shunt circuit, and then we find that we are wasting a large amount of power in this shunt circuit. Unless this power is at disposal, it may prevent us from practically employing this method. But fortunately there exists another method of dealing with the matter.

In my first lecture I pointed out to you that when a transformer is being worked on open secondary circuit, or is very lightly loaded, the potential difference between the ends of the primary circuit is exactly opposite in phase to the secondary circuit of the transformer, of which the primary circuit is connected to the extremities of the circuit in which the power to be measured is taken up (see Fig. 4). We shall still have an arrangement in which the current in the shunt circuit of the wattmeter can be made to be in step with the potential difference between the ends of the inductive circuit, all other arrangements remaining the same, but in which the total power taken up in the wattmeter is very much less than in the former case.

Fig. 4.

To show the difference between these two methods let us suppose that, in the first place, the wattmeter had a shunt resistance which could carry suitably one ampere, and that it is required to use this wattmeter to measure the power taken up in the primary circuit of the transformer at a pressure of 2,000 volts. We should then have to provide a non-inductive resistance capable of carrying one ampere at 2,000 volts, or nearly 2,000 watts expended on it. Under these circumstances, the power wasted in the shunt circuit of a wattmeter would be nearly 3 h.p. If, however, we do away with the non-inductive shunt resistance and take a 1 h.p. transformer capable of transforming down from 2,000 to 100 volts, and put the shunt coil and the wattmeter together with a small additional resistance across the secondary terminals of this transformer, so arranging the resistance that still one ampere flows through the shunt circuit of the wattmeter, we then have the following power absorptions:

The wattmeter shunt circuit will absorb 100 watts, and the transformer can be made to take as little as 60 or 70 watts, hence the whole arrangement—transformer, wattmeter, and additional resistance—only takes up 150 watts instead of 2,000; in other words, a saving of $92\frac{1}{2}$ per cent.

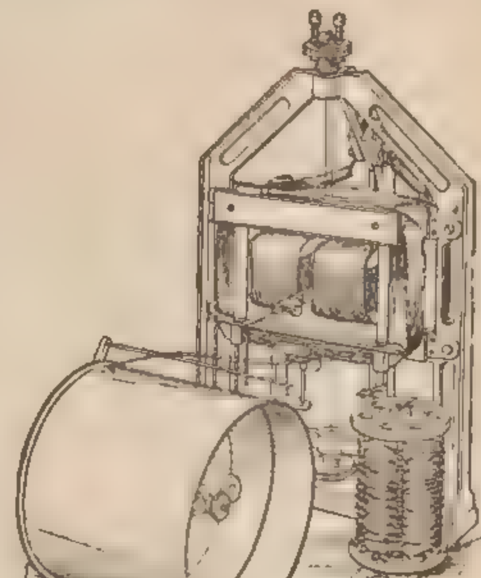


Fig. 5.—Mengarini Wattmeter.

It is clear, therefore, that the combination of the wattmeter with the transformer in this fashion is more economical than the use of a non-inductive external resistance. Generally, we may then say, that for the purpose of measuring alternating current power, the best instrument to employ is the dynamometer wattmeter; using either one of the Siemens form, in which the torsion of a spring is employed, or a balance form similar in construction to the ampere balance of Lord Kelvin. In those cases in which the

potential differences between the ends of the circuit in which we wish to measure the power absorption does not exceed 100 volts the whole, the necessary resistances can be placed in the movable coil itself, winding it at a high resistance, so that we have as few turns as possible in that coil and yet obtain the necessary magnetic moment. We can then apply the wattmeter, standardised as above described to measure the power taken up in any circuit inductive or non inductive. Many such instruments, lent by Messrs. Siemens Bros., Messrs. James White, of Glasgow, and others, are before me on the table.

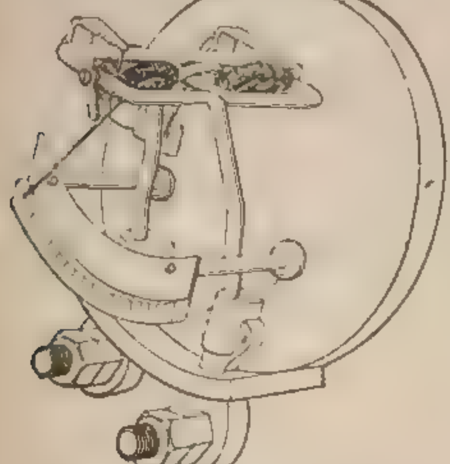


Fig. 6.—Engine-room Wattmeter.
General view of instrument, with case removed.

When we have to measure the power taken up by any inductive circuits, particularly when we are employing high pressures, as in measuring the power absorption in the primary circuit and transformers, then the best method to adopt is to use a transformer in connection with the dynamometer wattmeter, as above described. There is before me one interesting and novel form of wattmeter for use on alternating current circuits, which has been lent to me by Lord Kelvin. The instrument consists of a coil of one or two thick turns of copper wire, and a spectacle shaped fine wire coil in series, with an external resistance The instrument is adapted as a central station wattmeter, giving indications of power passing through it by means of the movement of a needle attached to the fine wire coil over a scale.

The interior is shown in Fig 6. It has a main circuit formed of a double rectangle of copper rod having sufficient area to carry 200 amperes, and a shunt circuit with two fine wire coils astatically arranged The main coil is mounted on a slate back, so that the rectangles are horizontal. The shunt coils are mounted on a light but strong aluminium frame in the manner shown in Fig. 7. One end of this frame has a circular knife edged hole fixed to it, and the other end has a straight knife edge. These two knife edges rest on two phosphor bronze hooks attached by insulating supports to the outside ends of the double rectangle By this method of suspension complete freedom from friction is obtained, while the movable system is kept in a definite position without end guides.

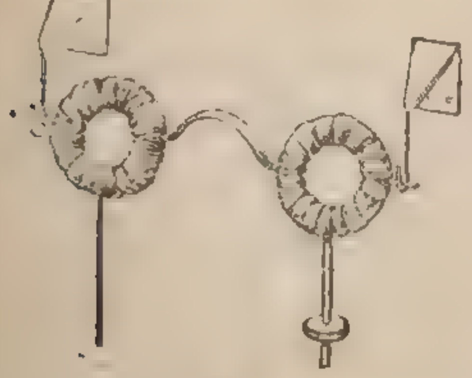


Fig. 7.
View of fine wire shunt coils, showing details of suspension springs removed.

Each fine wire coil has about 1,000 turns of insulated wire, and its resistance is about 100 ohms. The current is conducted in and out from the movable system by two flat palladium spiral springs, which also supply the restoring force for governing the sensibility of the instrument. Not more than $\frac{1}{10}$th of an ampere is allowed to pass through the fine wire circuit, and in order to regulate this a large non inductive resistance is rolled on the case of the instrument, which offers a large cooling surface. The scale has nearly uniform divisions, and is graduated to read directly in watts or kilowatts as required.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended August 25 were £2,810.

School Offices.—The new and extensive School Board offices now being erected on the Thames embankment should be lighted by electricity.

Woolwich.—Messrs. Reid Bros., of 12, Wharf-road, City-road, N., are now completing the laying of mains for the electric lighting of Woolwich.

Tokio.—The Yokohama Electric Light Company's dividend for the half year is 5 per cent., and the Tokio Electric Light Company has declared 7·6 per cent. for the half year.

St. Pancras.—The St. Pancras Vestry have accepted the tender of Messrs. Johnson and Phillips for their "D. P." accumulators, for the extension of the Regent's Park central station.

Thames Conservancy.—The new offices of the Thames Conservancy on the Victoria embankment are approaching completion. Who intends to secure the contract for wiring the buildings?

Personal.—Mr. Robert Hammond has been appointed consulting electrical engineer to the Corporations of Newport (Mon.) and Wakefield, to carry out the electric lighting work under the provisional order.

Aberdeen.—The Gas Committee of the Town Council have agreed to instruct Mr. Murray, the electrical engineer, to go to London for a week to inspect the plant that is being made for the new electric lighting station.

Marine Signals (Barker's) Syndicate, Limited.—This Company has been registered with a capital of £6,000 in 5s. shares to carry into effect an agreement and to carry on business as engineers and signal manufacturers.

Partnership.—A gentleman desires to purchase or take a share in an established London electrical business. Communications on the subject are to be sent by principals (or solicitors) to Chas. Richardson and Co., 342, Strand, W.C.

City and South London Railway Company.—The receipts for the week ending August 27 were £716, against £805 for the same period last year, or a decrease of £89. The total receipts for the second half year of 1893 show an increase of £438 over those for the corresponding period of 1892.

Richmond.—The 30 men employed in the construction of the electric light undertaking at Richmond, and who went out on strike a week ago in protest against the dismissal by the engineer of three of their number without reference to the foreman, returned to their work on Tuesday morning.

The City.—At the fortnightly meeting on Tuesday of the Guardians of the City of London Union, the Thavie's Inn Committee reported that they had resolved to leave the matter of the electric lighting tubes, found under the paving near the walls next Robin Hood court, in the hands of Mr. W. M. Cross and Mr. Boyle, with power to confer with the clerk and architect thereon.

Getting Too Busy.—On enquiring recently as to the prospects of business, one very prominent company which manufactures and contracts for the equipment of central stations seemed to think that they were going to have really more work than they could get through in the time, and might be compelled to ask for a little indulgent delay from their customers, so long as there are only 24 hours in the day.

Derby.—The Chairman of the Derby Gas Company, speaking at the half yearly meeting on Wednesday, said that the electric light had been introduced into the town, and that before the next half year it would be in many of the shops. That might have some effect upon the gas company, but he was not afraid of it, and he could assure the company it would not affect the maximum dividends at present.

Testimonial.—We are informed that Mr. Vincent Swindells, who has been connected with the New Telephone Company at Manchester, and with its predecessor, the Mutual Company, from its commencement, has been presented with a handsome testimonial by his late colleagues on the occasion of his resignation. Mr. Swindells will now represent the Fowler Waring Cables Company in the North of England.

Lighting at Burnley.—The electric light station commenced to supply current for the first time last week Two large lamps in the centre of the town were the first to be lighted. The new illuminant has not yet been used at the Town Hall, but it will be in operation in a few days. A search-light will also be placed on the top of the Town Hall. The current has been switched on to the shop circuits, and various tradesmen's premises are now electrically lighted.

Huddersfield.—An installation of the electric light has been fitted in the Huddersfield Parish Church. While the church was being fitted with the light it was also cleaned and decorated, and the general improvement effected in the appearance of the edifice has been very marked We understand that the Huddersfield suburban extension of the municipal station is now being proceeded with, and that Messrs. Reid Bros., of 12, Wharf-road, City road, London, N., are the contractors for the work.

Government and the Telephones.—In the House of Commons on the 28th ult., Mr. Arnold Morley, replying to questions by Mr. Maclure and Captain Bagot, said the particulars of the agreements between the Post Office and the National Telephone Company were now under the consideration of the Government and he trusted that no undue delay would arise in [illegible] agreements. When the trunk lines were un[illegible] Post Office no priority would be given to an[illegible]

Shiplighting.—We are informed that Messrs. W. C. Martin and Co., electrical engineers, of 342, Argyle-street, Glasgow, have obtained a contract for the lighting of the new Leith and London steamer. The installation is to comprise 200 lamps and duplicate engine and dynamo. The same firm have also received the contract for the installation to be fitted on the ss. "Stirling," now being constructed by Messrs. W. B. Thomson and Co., Limited. Messrs. Martin and Co. have also a contract for the fitting up of electrical machinery on board two steamers now building at Belfast.

Lighting of Rolling Mills.—We understand that Mr. T. Scott Anderson, of Royal Insurance-buildings, Sheffield, has recently obtained orders from three of the largest rolling mill firms in Sheffield to put up complete installations, and that the workmen highly appreciate the arrangement of 300 c.p. incandescent lamps near the rolls. Mr. Anderson has now in hand a large installation for a wire rolling mill, and which will comprise 13,000 lamps. This will be the largest installation in the town. A complete plant for a dairy has also been supplied for the operation of cream separators, churns, etc.

Chertsey.—At a meeting last week of ratepayers, the chairman mentioned that a resolution was passed last year requesting the inspectors to enquire the terms upon which the area could be lighted by electricity, and report to a meeting as soon as possible. He wanted to know whether any enquiry had been made, and, if so, why the inspectors had not reported to the meeting as stipulated in the resolution. Mr. Webb replied that they had advertised, and had received several replies, but owing to red tapeism, provisional orders, and so on, they were not prepared to report at the present time, although an offer had been made conditionally by a corporation.

New Swindon.—During the meeting held last week of the members of the Local Board the question of gas and electricity came up. Mr. Jones suggested that a statement should be prepared of the cost of gaslight in the district up to Midsummer Day last, so that the members might have it for reference when dealing with the question of electric light. The Vice-Chairman said in that statement they would have to take into consideration that part of the district comprising new streets which were not at present lighted with gas. Mr. Fox said this matter had been fully discussed by the committee, and he did not think it was necessary to go further into the matter at this stage.

Edinburgh.—A meeting of the Sub-Committee of the Cleaning and Lighting Committee of the Town Council has been held with reference to the electric light installation at the Powderhall destructor. It was arranged that the destructor should be opened with some sort of ceremony on the evening of September 11, and that the Lord Provost should turn on the electric light at eight o'clock. In addition to members of the Corporation of Edinburgh and their friends, members of the Leith Corporation and other persons interested are to be invited to the ceremony. The destructor is being gradually got into working order and is even now disposing of about 40 tons or more of refuse in the 24 hours.

Europe and Azores Telegraph Company.—This Company has been registered with a capital of £200,000 in £10 shares. The object is to acquire a concession granted by the Government of Portugal to the Telegraph Construction and Maintenance Company, Limited, for the establishment of a submarine telegraph cable between Portugal and the Azores Islands, and for the laying of like cables between certain of those islands; to acquire and turn to account patents and inventions relating to telegraphy, and to construct, maintain, and work telegraphs, telephones, and electric light works, etc.; to manufacture telegraph and telephone wires and cables, and to carry on the business of telegraphy and the transmission of messages in all its branches. The first signatories are Sir J. Pender, G.C.M.G., M.P., Marquis of Tweeddale, T. Fuller, A. J. Leppoc Cappel, K.C.I.E., J. D. Pender, W. Shuter, and G. H. Richards.

Scarborough.—The Scarborough Electric Supply Company, Limited, commenced the supply of electricity on Saturday. At present the current is only available in a portion of the town, but the remaining connections are being completed as fast as possible, and it is expected that in the course of a week or two the whole of the mains will be completed. The company was formed at the end of last year by Mr. A. A. C. Swinton, under an agreement with the Corporation of Scarborough, and is working under a transfer of the provisional order obtained by the Corporation. The high-tension alternate current system, with low-tension distribution from sub-stations, is employed. The charge for electricity is at the rate of 7d. per Board of Trade unit, with a cash discount and a sliding scale rebate amounting to 20 per cent. as a maximum for large consumers. Colonel R. F. Steble is chairman, and Mr. A. A. C. Swinton, managing director and engineer-in-chief to the company. The electric generating plant and transformers have been supplied by Messrs. C. A. Parsons, of Heaton Works, Newcastle-on-Tyne.

Elmore Copper.—In a letter published in the *Financial Times* of Wednesday, "O. O." states: "Can nothing be done to make the Elmore Foreign and Colonial Company redeem its public guarantee to the preference shareholders, and pay the first year's interest of 10 per cent. They paid the first half on November last. The second half was due on May 1. No more has been paid. I parted with my £100 upon the direct representation of the company that they would pay the first year certain, and even this, with the usual consistency and truth that characterise all their statements, they represented would not be required of them, as the French Company would have almost unlimited means to pay *all demands out of profits* without calling upon them. Now, sir, *when you apply to the company they try to shift* their obligation upon the New French Company, 'who, by the way, I should like to hear something about,' and say they are pleased to say that with the new company provision has been made for the outstanding dividend due. I trust that some shareholders will bestir themselves, and through your columns bring these persons to account."

Mining Machinery.—The Jeffrey Manufacturing Company, who have had over 20 years' experience in the manufacture and application of mining machinery in the United States, have decided to introduce their machines to the colliery proprietors of Great Britain. Mr. Job, a mining engineer of great experience in machinery for developing coalfields in the States, has recently visited this country to ascertain the conditions and requirements of the various seams and methods of working, and has now returned to the States to have the machine modified to suit the "long wall" system of mining. The types of machine which have survived the experimental stage are that for undercutting coal which takes a cut 3ft. wide and up to 6ft. deep in about 20 minutes, and a drill which bored a hole for blasting 2in. diameter by 6ft. deep in about two minutes. The English business will be worked by Messrs. John Davis and Son, of Derby, London, and Cardiff, who have undertaken the management for the United Kingdom. The motive power is usually electric, and the machines for safety lamp pits will be fitted with the Davis and Stokes safety motor.

Bath.—At the fortnightly meeting of the Sanitary Committee of the Town Council, Mr. H. A. Simmons complained of the nuisance caused by the smoke from the electric light works. The inspector said on the 24th ult. he served a notice on the company to abate the black smoke nuisance within four days, and also one giving them seven days to make the furnace apparatus perfect. The company had ceased to use a smoke consumer they formerly had in the chimney. A letter from the manager stated that the company had been unable to get smokeless coal owing to the strike, and that if the notice were followed up the plant would have to be shut down and the supply of light to the city discontinued. It was decided to call upon the company to replace the smoke consumer, but not to take other steps for the present. **At a meeting of the Surveying Committee of the Town** Council, Mr. Gatehouse's charges of £50. 4s. for examining the electric light for the half year were presented. Mr. Taylor asked whether the examination was carried out at the works or at Mr. Gatehouse's offices. Although the machinery for testing might involve some expense, he thought it would be more satisfactory that he should make the examination at his offices than at the works. Mr. Sturges promised to bring up a report on the matter at the next meeting.

Electric Lighting for Dewsbury.—Mr. F. H. Tulloch, one of the inspectors of the Local Government Board, held an enquiry on Tuesday at the Town Hall in respect to an application made by the Dewsbury Corporation to borrow £25,000 for electric lighting. The Mayor of Dewsbury, and several members of the Corporation, and Mr. A. H. Preece, son of Mr. W. H. Preece, engineer, of London, were amongst those present. The Town Clerk (Mr. E. Mawdesly) said the Council had come to the conclusion that an installation of the electric light was necessary in the interests of the town, and they found there was a demand for it. They sought the best possible advice, and Mr. W. H. Preece, of the Post Office, London, drew up specifications. Tenders had been accepted, and in mentioning that the successful firms were Messrs. Siemens and Co. for street main work, Messrs. Crompton and Co. for engines and generating plant, and Messrs. Horsfield for supplying boilers, he thought that was sufficient evidence of the works being satisfactorily carried out. The Corporation did not propose to expend the whole of the £25,000 immediately. It was thought the present system of lighting the streets with gas was sufficiently good. The Corporation had expended large sums of money on the gasworks, yet they believed that by adopting the best possible system of electric lighting, and at a price which would enable persons to become customers, there would be a profit which would counteract any loss from the gasworks. There was no opposition, and after Mr. A. H. Preece had explained the extent of the scheme the enquiry was concluded.

Bristol.—The question of insuring the new buildings was under the consideration of the Electrical Committee of the Town Council at their last meeting. Mr. Kapp, one of the consulting engineers, and Mr. Henry Williams, the architect, were present at the meeting, at which it was reported that no fewer than 30 tenders had been received from different insurance offices, but the rates quoted by some of the competing companies were much higher than was anticipated by the committee. This led to a suggestion that it would be advisable for the Corporation to themselves establish a system of insurance for all their property, but no definite proposal arose out of the discussion, and at length it was decided to effect an insurance upon the building itself. Some appointments were made on the electrical staff, and it was left to Mr. Kapp and Mr. Faraday Proctor to recommend two candidates for appointment as assistant engineers. At the industrial exhibition opened this week, one of the chief attractions is the prismatic fountain in the art section. The jets consist of a heavy and copious one in the centre, 20 mist jets immediately surrounding it, 16 straight jets a little farther removed, and a number of spray jets affixed around the border of the fountain. At the eastern end is also a prettily arranged cascade. In all there are five separate sources of water supply. Underneath the central jets is a series of 16 watertight boxes, and there is a large lantern in the roof exactly over the central stream. The electric lights and coloured screens in these and the jets of water are controlled from a chamber in the south gallery, where by means of ingenious contrivances the streams can be raised or lowered, and otherwise

varied, and the lights can be manipulated so as to produce the most charming effects. The electrical work of the fountain has been well and admirably carried out by Messrs. F. W. Ball and Co., Bristol.

Cable between Australia and America. Mr. Hogan a few days ago asked the Postmaster General whether he had observed in a daily paper a despatch from Berlin stating that the cable from Australia to New Caledonia, constructed by a French company, was the first section of a cable service from Australia to America *via* Samoa and Honolulu, and that the German Imperial Post Office had expressed its readiness to grant a subsidy towards the construction of the Samoan connection; whether he had any information that would throw light on this alleged intention to construct a complete cable service under foreign management and control between Australia and America; and whether any steps had been or were being taken to give effect to the strongly expressed wishes of the Australian and Canadian delegates to the Imperial Conference held in London in 1887 in favour of the construction of a Pacific cable under British management and control. Mr. A. Morley: The answer to the first paragraph of the hon. member's question is Yes, but I have no official information which bears out the statement. As to the second paragraph, the agreement which has been entered into by the French Government with a company for a cable from Queensland to New Caledonia has been published, and I shall be glad to let the hon. member see a copy if he wishes. I am not aware of any steps having been taken to lay a cable under British management and control, but I ought to add that, as subsidies to submarine cable companies are not borne on the vote of the Post Office, the question is not one under my special control.

Babcock and Wilcox, Limited.—The second ordinary general meeting was held on Wednesday, at Cannon-street Hotel, E.C., Mr. Andrew Stewart, the chairman, presiding. The Chairman said that they had paid to the shareholders for the half-year ended December 31 last an interim dividend of 10 per cent. on the ordinary and 6 per cent. on the preference shares, which absorbed £10,000. They now proposed to pay 10 per cent. on the ordinary shares and 6 per cent. on the preference, absorbing £10,000, the total dividends payable for the year being £20,000. They had, in addition, written off the sum of £11,328 for the purchase of business account, and would carry to the credit of next year the sum of £9,547. The plant and machinery were kept in an efficient condition for the economical and successful production of the patent boilers, and, to still further aid that purpose, they have made additions to plant account for last year amounting to £1,913. They had, as compared with last year, not been able to obtain the same success financially, due to the very bad trade and the scarcity of orders in every market open to their efforts at home and abroad. Still, they considered the results and the income earned as, on the whole, very satisfactory. The three most gratifying facts in the directors' experience during the past year had been, first, the steady progress which the boiler was making in the old markets into which it had been introduced, and the favourable returns from the new markets which they had been and were exploiting; the second was still more important, viz., the high appreciation of the boiler by those who had been using it, the fact being that not less than 50 per cent. of the orders coming in were from those who had used the boilers before; the third was the progress making in improvements on the boiler and auxiliary matters connected with it, which they believed would keep it well ahead of manufacturers of boilers working in the same direction, largely due to the excellent staff employed, but still more to the able management of the acting directors. He then moved the adoption of the report and accounts, and the payment of the dividends. The resolutions were carried.

Lighting of Aberdeen.—It is more than 10 years since the subject of the introduction of the electric light into the city of Aberdeen was mooted at the Aberdeen Town Council, but it was not until 1890, when the Aberdeen electric lighting order was obtained, that any real progress was made. By that order power was taken to supply the whole city with the electric light, but the compulsory area which the Corporation in the first place undertook to supply was limited to Union street (from the Town House westward to Bridge street), Market street (between Union street and Guild street), Broad street, St. Nicholas street, School hill, and Union terrace. The whole scheme was to be worked in conjunction with the gas undertaking, an arrangement which was, on the face of it, the most economical and efficient that could be devised. In July, 1892, there was submitted to the Town Council an elaborate report by Prof. Alexander B. W. Kennedy, F.R.S., M.I.C.E., on the best method of supplying the electric light to shops, offices, public and private buildings in the city, the lighting of the streets not being then in contemplation, although provision has now been made for its introduction at a future period. That report formed the basis of the system which was finally adopted by the Town Council and which is now in process of installation. The system adopted is one by which the electrical energy is generated at a station in the immediate vicinity of the gasworks, and distributed to the area already referred to by means of copper strips resting on porcelain insulators, and laid in a concrete culvert. In order to provide for the 7,000 lamps which it is proposed to supply with the electric light within the area, the station in Cotton street is in course of erection. This building is planted within the grounds of the gasworks, and can thus be economically supplied with coal for the works by the waggons and locomotive which run past the building. The station consists of three main parts—the boiler room, the engine and dynamo room, and the switchboard room, occupying the upper part of the building. There are in the basement four Babcock and Wilcox boilers, which supply the engines with motive power. There are five engines, three of these being each of 80 h.p., the other two being capable of indicating 40 h.p. The five engines drive the dynamos direct. In another part of the building are the storage cells. Including all the buildings and plant the cost of the installation may be roughly estimated at £24,000. The entire cost will fall on the gas undertaking of the city, and it will take some time before the whole area is supplied up to the capacity of the engines and dynamos at the central station. When the whole 7,000 lamps are in operation, the Council will probably be prepared to face the further extension to the western district of the city, which will be accomplished at a further cost of about £20,000. When the installation is complete the central station will be able to supply 10,000 lamps of 8 c.p.

Kelvinside Central Station.—The directors of the Kelvinside Electricity Company, Limited, invited, on Monday, a select company to be present at the starting of the Kelvinside electric light station, Hughenden road. The Act of Parliament confirming the rights to supply electricity to the district of Kelvinside was granted at the same time as the Glasgow Electric Lighting Act, but not having the financial resources of a city at their back the company have not been able to get into working order quite so quickly as Glasgow. The few months' delay, however, in opening has enabled the company to profit by the experience, not only of Glasgow, but of various other towns having electric lighting in progress. The result is seen in the supply station now ready for work. The buildings are situated about 100 yards north-west from Hyndland road railway station, and are built of a fine quality of brick, specially selected for its pleasing red colour. The works are so designed that the portion now built, while in itself complete and perfectly equipped, forms only a part of a larger station, the completion of which can be accomplished without interfering with the part already at work. The coal bunkers, of about 6,000 cubic feet capacity, are so placed that coal can be obtained direct from the railway waggons, and so constructed that the coal falls towards the furnaces, and is delivered at the furnace mouth with the minimum of handling. Provision is made in the complete station for 10 high-pressure boilers of 150 h.p. each, two of these boilers being already in position and under steam. The portion of the engine and dynamo room now built measures 67ft. long by 25ft. broad by 31ft. high. The foundations already in are suited for six engines and dynamos of 120 h.p. each, two of which are in operation. Each of these can supply 1,500 incandescent lamps of 10 c.p., or 1,000 of 16 c.p. In addition there are in an adjoining compartment accumulators of the largest type made. A gallery, which runs the whole length of the engine room, contains the switchboard and instruments mounted on white marble panels, and leads to the store room. Underneath the station a subway gives access to the conductors between the dynamos and switchboards and to the end of the feeder mains which carry the current over the Kelvinside district. Over 10,000 yards of feeder and distribution mains are already laid under the streets from which the earliest demand is expected. Houses are already wired for a total of 1,500 lamps of 16 c.p., and a number of others are in progress or under negotiation. The area over which the lighting extends is bounded on the east by Byres road, the west by Bingray road, the north by Winton drive, and the south by Dowan hill. The buildings and the installation generally have been designed by and carried out under the superintendence of Mr. John M. M. Munro, M.I.E.E., of the firm of Anderson and Munro, of Glasgow, and Messrs. Sharp and Kent, of London, have been the contractors for the whole work, their representative being Mr. Elsden Dew, A.I.E.E. The switching on ceremony was performed by Miss Elsie Munro.

Windsor and Eton. Mr. A. E. Farrow has written to the *Windsor Gazette* as follows: "The provisional order granted to the Windsor and Eton Electric Light Company embraced too large a district to prove remunerative to its shareholders, and had the company laid mains all over the area which the provisional order included, Windsor would be in the unenviable position of having by far the least number of lamps per mile of main than any supply company in existence. Datchet, which is included in the order, is too far from Windsor, and the demand for electric light is also too small to prove in any way remunerative. Assuming there is a demand for a thousand lamps in Datchet (which is about the number required there), to supply them from Windsor means laying down duplicate high-tension dynamos at the works here, and an expensive $2\frac{1}{2}$ miles of highly insulated cable, also a station at Datchet, with motor transformers and accumulators to supply the customers there with low-tension electricity. If alternating currents were employed, it would mean a double set of men in the station at Windsor to comply with the regulations of the Board of Trade. Regarding the supply, the best system of electric light to adopt in Windsor would be the low-tension three-wire system; as the consumers are all within a half-mile radius of the supply station, assuming, of course, that the new works will be where the old ones are. The station ought to be built to be able to contain enough machinery for 9,000 lamps, and equipped with the necessary engines and boilers for 3,500 lamps, which there is an immediate demand for. The additional machinery could be installed as required. The approximate cost of building the above, with all necessary boilers, engines, dynamos, accumulators, etc., for 3,500 lights of 8 c.p. would be about £9,000. To lay down mains from supply works to Peascod street, along up Peascod street to High-street, down Peascod street to Osborne-road, to extend along High street to the lower end of Frances road ... street, also down Thames-street to Windsor ... should be laid with enough copper to ...

should also have necessary feeders to keep the pressure as near as possible constant These would form the principal mains, and less expensive ones could be laid in the side streets whenever required The cost of mains, including the laying down in the above streets, would be about £4,000 Thus, with the purchase of land, law and incidental expenses, the cost would be about £14,000 As to the income to be derived from the sale of electricity, of course the first year the station would only about pay its expenses, but it is certain that in the second year there would be quite 3,500 lamps on Now, a fair average consumption of electricity for an 8 c p. lamp per year is 25 units, so that 3,500 lamps, taking 25 units each per year at 8d. per unit means £3,750; the cost of the works would be about 4½d. per unit; there would therefore be a saving or profit of £1,693. Of course, as the demand increased, the price per unit would be less, and if street lighting with arc lamps were introduced, the works would pay a very good dividend."

Electric Lighting at Taunton. On the 22nd ult. the report of the Electric Lighting Committee was presented at the meeting of the Town Council It was as follows "The committee recommend that the purchase of the electric lighting works be completed on September 30 The committee recommend that some practical electrical engineer be appointed to advise the Corporation as consulting engineer They herewith present a letter from Dr J. A. Fleming, offering to act in that capacity for 12 months for 25 guineas and travelling expenses The committee recommend that he be appointed accordingly Your committee have instructed a sub-committee to consider several matters and report to the Council thereon The sub-committee report as follows: They recommend that the services of Mr Henry Everard Hunt, the electrical engineer, be continued at his present salary of £150 a year, subject to three months' notice on either side. That Mr Hunt be allowed to take such pupils as the committee shall from time to time consider advisable, and that one half of their premiums be paid by him to the Town Council That engine drivers, stokers, trimmers, and labourers be under the control of the electrical engineer for the time being, subject to the approval of the committee. The sub-committee have instructed the borough surveyor to check with Mr. Hunt the places for stores with the inventory taken while negotiations were being made for the purpose of the works They recommend that advertisements and notices be given stating that the Council are prepared to receive at once applications for the 1st day of October next. They also have recommended that as the duties as Electric Lighting Committee will cease as soon as the purchase of the works is completed, a committee be now appointed to make arrangements for carrying on the business of the electric lighting works after the time, and that such committee be authorised to consider such arrangements at once." Alderman Chapman, in moving the adoption of the report, remarked that they had passed from the stage of general discussion as to whether they were right or wrong in acquiring the electric light works. It now became their duty to pass such resolutions as were necessary to carry on the works and other matters of detail. As regards the date for completing the purchase it was suggested to be the 30th September, to allow sufficient time for the preparation of the necessary deeds, and also as being a convenient date for the change to take place It was also suggested that advertisements be issued to inform the public that the electric light would be supplied after a certain date. That should be done because it was understood that some people had been waiting to know when it could be done. There was an erroneous opinion abroad that the light could not be carried to the extreme parts of the borough, it should be known that the system was sufficiently powerful to carry the current as far as the Wesleyan College on Haines Hill. The report was adopted. In place of the old committee the following gentlemen were appointed as the Electric Light Committee to manage the works: Messrs. Van Trump, W. M. Chapman, A. Goodman, W. Potter, A. Hammett, A. Steevens, J. Goldsmith, R. U. Hartnell, and J. P. Sibley.

PROVISIONAL PATENTS, 1893.

AUGUST 21.

15781. **An improved system of electric wiring.** Thomas Pattison Rennoldson, Banbridge, co. Down, Ireland

15789. **An automatic method of starting and stopping the paper of Morse telegraph or other recording instruments.** John Peter Gorton, The Commercial Cable Company, Weston super-Mare.

AUGUST 22.

15906. **Improvements in and relating to electrolytic apparatus.** David Young, 11, Southampton buildings, Chancery-lane, London. (La Societe Oatheme Chalandre Fils and Cie., France.) (Complete specification.)

AUGUST 23.

15907. **Improved insulator for telegraph and telephone wires.** Henry Koster, 9, Warwick court, Gray's inn, London.

15938. **Improvements in telephones.** Alexander Spark, 4, Belmont street, Aberdeen.

15957. **Improvements connected with assistant or auxiliary electromotors.** La Societe Anonyme pour la Transmission de la Force par l'Electricite, 6, Lord street, Liverpool. (Date applied for under Patents, etc, Act, 1883, Section 103, 15th March, 1893 being date of application in France.) (Complete specification.)

15962. Improvements in electric indicators. Berthold Zeitschel, 40, Chancery-lane, London. (Complete specification.)

AUGUST 24.

15971. **Electromagneto motor for maintaining uniform speed.** George Lee Anders and Walther Kottgen, 10, Jeffreys-square, St. Mary's axe, London.

15974. **A new form or construction of tube or pipe for carrying or supporting electric wires underground.** John Johnston Green and William Oates, Commercial-street, Halifax.

15997. **Improved electric high-tension fuse head for use in blasting.** Tom Malson, Sidney Richard Malson, William Albert Malson, and Emmanuel Smith, 3, Chichester rents, Chancery lane, London (Complete specification.)

16000. **Improvements in telegraphy** Charles Arthur Allison, 52 Chancery lane, London (Pierson J. Wicks, United States (Complete specification.)

16008. **Improvements in or relating to multiple telegraphy.** Alfred Piedfort, 323, High Holborn, London. (Complete specification.)

16017. **Improvements in electrically-actuated machine tools.** Henry William Gibbs and George James Gibbs, 4, South-street, Finsbury, London.

16019 **Improvements in metal posts or supports for electric wires or cables, also applicable for other purposes** Oscar Andre, 24 Southampton buildings, Chancery lane, London. (Complete specification.)

16025. **Automatic coupling for electromotors** Siemens Bros. and Co, Limited, 28 Southampton buildings, Chancery-lane London Siemens and Halske, (Germany.)

16026 **An automatic regulator for dynamo-electric machines.** Siemens Bros and Co, Limited, and Ernest Holmes, 28, Southampton buildings, Chancery lane, London.

16027. **Improvements in connections for local supply from electrical mains.** Siemens Bros and Co, Limited, and Harry George Knorr, 28, Southampton buildings, Chancery lane, London (Complete specification.)

16028 **A method of compensating variations of load at electrical stations** Siemens Bros and Co, Limited, 28, Southampton buildings, Chancery lane, London. (Siemens and Halske, Germany.)

AUGUST 25.

16060. **Improvements in electric arc lamps.** George Theodore Pardoe and George Broughall, 4, St. Ann's square, Manchester.

16074. **Improvements in apparatus for lighting gas by electricity.** Adolf Geyer and Johann Stegmeier, 37, Chancery lane, London. (Complete specification.)

AUGUST 26.

16133. **Improvements in electrical devices for opening doors.** William Phillips Thompson, 6, Lord street, Liverpool. (Hermann Schultze, Germany.) (Complete specification.)

16136. **Improvements in or relating to electrodes for primary and secondary batteries** Alfred Julius Boult, 323, High Holborn, London Rudolph Theodor Ernst Hensel, Germany.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1889

14867. **Electrical conductors.** Imray (Walton.) Second edition.)

1892.

14658 **Secondary batteries.** Smith.

17643 **Electric switches.** Edmunds.

17922. **Secondary batteries** King and Clark

24127. **Secondary batteries.** King.

1893.

2161. **Heating liquids by electricity.** Miller and Woods.

9039. **Autographic telegraph apparatus.** Denison.

9819. **Electric circuit controlling devices.** Hall.

11464. **Galvano-electric belt.** Thompson. (Biermann.)

11819. **Electric railway trolleys.** Allen.

12374. **Electric lamps.** Gover.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	–	3¼
— Pref.	–	2¼
City of London	–	11
— Pref.	–	12¼
Electric Construction	–	—
Gatti's		5¼
House-to-House	5	3¾
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	[illegible]	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	–	6
National Telephone	5	4¾
St. James', Pref.	—	8
Swan United	3¾	3¼
Westminster Electric	—	5¼

NOTES.

Poitiers.—The Blossac Park is to be lighted electrically.

Auterive.—A central station has just been set in operation.

Milan.—An electric railway is projected between Milan and Vilanterio.

Zermatt is to be lighted electrically by the Vevey Construction Works.

Theatrephones.—Several theatrephones have been established at Cardiff and Bristol.

Adding Apparatus.—An adding machine has been invented by Mr. A. Erskine Muirhead, of Glasgow.

Rome.—The Banca Nazionale in Rome will shortly be equipped with 11 electromotors for ventilating purposes.

Long-Distance Telephony.—Telephonic communication between Stockholm and Christiania was started on Saturday.

Caen.—A central station is to be built here, and the price for light will be lower than that charged for gas illumination.

Electric Locomotives.—Four of the principal French railway companies are said to be making experiments with electric locomotives.

Calais.—The Calais Gas Company has been granted a concession for the electric lighting of the town, the work to be completed by the end of November.

Private Bills.—Among the principal private Bills considered this session have been those for the extensions of the underground electric railway system in the metropolis.

Artificial Diamonds.—It is believed that M Moissan will exhibit at the forthcoming meeting of the British Association some artificial diamonds prepared in his electric furnace.

High Speed.—We wonder whether it is correct, as reported, that a locomotive, designed by Mr. M. Reynolds, of Wolverhampton, is now being constructed to run at 100 miles an hour.

Essen.—The electric tramway from Essen to Borbeck and to Altenessen, equipped by the General Electricity Company of Berlin, was opened to traffic on Wednesday of last week, 13 cars being put into service.

Copenhagen.—A new telephone station is being constructed for the Copenhagen Telephone Company. It will have accommodation for 10,000 subscribers, and arrangements are being made for a double-wire system.

Stettin.—The central station established here in 1889 by Messrs. Siemens and Halske was extended last year by the addition of two new dynamos and a battery of accumulators. There are now at work four engines of a total of 900 h.p.

British Museum.—The annual account and return of the British Museum states that preparations are being made for the installation of incandescent electric lamps in the reading-room, and which will be completed before the autumn.

Berlin.—The extension in the use of the electric light in private residences is attributed as the cause of a diminution in the consumption of gas in Berlin during the first quarter of the present year. This is rather surprising, as the converse is generally the case.

Refuse Destructors.—The Powderhall district of Edinburgh has been supplied with a refuse destructor, the heat from which, as mentioned last week, is to be used in connection with the electric light plant laid down on the spot for the illumination of the buildings.

Edison.—It is said that Edison's father, Samuel Edison, is now 90 years of age, and expects to live some years longer, as his father was 103 years old, and two aunts were 99 years respectively at the time of their deaths

Tramway Congress.—The sixth International Congress on Tramways and Street Railways was opened yesterday at Budapest. Among the subjects under discussion is the question as to the conditions under which electric power is preferable to animal or mechanical power.

Blackpool Tramways.—A report by the electric engineer to the Corporation states that the electric cars cannot be successfully worked on the present system. The line, he states, costs too much to maintain. The Council have been informed that it will be necessary to adopt some other system of working the cars.

Friend or Foe.—In a paper read before the Pacific Coast Gas Association, Mr. J. L. Hallett, of Portland, Oregon, dealt with the question as to whether the electric light was a friend or foe to the interests of gas lighting. He concluded that much depended upon the quality and price of the gas sold, and on considerate management.

Remscheid Tramway.—The electric tramway recently set in operation at Remscheid comprises two lines of a total length of about five miles. It is arranged on the Thomson-Houston system, and the gradients range from ·2 per cent. to as much as 10 per cent. There are five cars in service, and the number will shortly be increased.

Subways.—The members of the Manchester District Institution of Gas Engineers on Saturday inspected the subways at Nottingham. These subways have been constructed to contain the sewers, gas and water pipes, electric light mains, and telegraph and telephone wires, so as to render these readily accessible without breaking up the streets.

Torpedoes.—Arrangements have now nearly been completed for important experiments by the United States Navy, at Newport, U.S.A., for launching the Sims-Edison electrical torpedoes from a steamer at sea with a view to introducing it as a naval weapon. Torpedoes of this type were adopted three years ago by the United States engineers for coast defence.

May Island Lighthouse.—The Lord Provost of Edinburgh and other members of the Board of Northern Lighthouses, have accompanied two German officers to May Island to inspect the electric appliances in the lighthouse. The visit was in connection with the proposal of the German Government to establish the electric light on Ruegen Island in the Baltic.

Mutual Induction and Capacity.—Messrs. Bedell and Crehore, in a pamphlet reprinted from the *Physical Review*, discuss this question in the general case of two independent circuits each of which contains resistance, self-induction, and capacity, and which are connected only by means of their common magnetic field. The investigation is intensely mathematical.

The Douglas Tramway.—Some experimental runs are in progress with the electric cars. The tram line passes round the bold headlands at the north end of the bay as far as Groudle Glen, and will ultimately be continued to Laxey, a distance of 10 miles. The experiments are being carried on under the superintendence of Dr. Hopkinson, and have been witnessed with considerable interest. All the lines have been laid.

Antwerp Exhibition.—An electrical committee has been formed in connection with the international exhibition to be held at Antwerp next year. The committee has been divided into three sections: (1) Scientific applications and measuring apparatus, presided over by M. Eric Gerard; (2) industrial applications, transmission of power, lighting, and production of electricity, of which M. Beliard is president; and (3) telegraphy and telephony, M. Banneux being president.

Electricity vice Cable.—It is said—though with just what authority one would at this distance hardly care to decide—that all the cable tramways in the city of Denver, Colorado, have been gradually transformed, and are now operated on the electric trolley system. As the cables wore out, the tramway company in each case, it is said, substituted electric traction appliances instead of buying new cables, etc., and the result is claimed to be all one could wish on the score of economy and better service.

Belem.—The Municipality of Belem, Brazil, invite tenders for the lighting of the town either by gas or electricity, or by both. Intending contractors must consider the charge for the light, its quality and intensity, the system adopted for its production, distribution, and maintenance, the length of the concession, the time necessary for commencing and for completing the work, and the nature of the currency in which payment is to be made. Tenders are to be forwarded by the end of October.

Signalling from Balloons.—One of the important features of the autumn manœuvres will, it is said, be the trial of an improved organisation in military aeronautics. In addition to taking photographs at greater heights than have hitherto been publicly recorded, improvements have been made in day and night signalling—the latter by electricity—from balloons between various components of the same force. Of course these signals might be read by the common enemy, but it would be easy to change a code of signals so that it could be read to any purpose only by the initiated.

Electric Powers (Protective Clauses).—There has this week been published by Messrs. Eyre and Spottiswoode the report from the Joint Committee of the House of Lords and the House of Commons on Electric Powers (Protective Clauses), together with the proceedings of the committee, minutes of evidence, appendix and index. The substance of the report has already been given in this journal on the occasion of the holding of the enquiry and in subsequent issues. The report will, however, form a valuable work of reference.

To Gauge Trembling.—A device termed a "tromometre" has been devised by Dr. Quintard for gauging the trembling of nervous people. It consists of a metal plate pierced with 20 holes of different sizes in a graduated scale, and a needle which the patient endeavours to put into the holes. When he succeeds in placing the needle in a hole, he completes an electric circuit, causing a bell to ring. The excessive indulgence in coffee and stimulants, as well as lead or mercurial poisoning, produce tremblings which it is said can be tested with this apparatus.

Car Accident.—The daily papers this week head a paragraph as "Fatal Electric Car Accident in Cincinnati," when the fact that electricity was used as the motive power had nothing whatever to do with the accident. The car, as has happened on various occasions with cable and steam cars, was proceeding at a rapid rate down a steep hill when it left the rails, and almost immediately overturned. The car, which had a full complement of passengers, was wrecked, two passengers being killed, and 40 persons receiving injuries of a serious nature. Of course an accident of this kind may occur with almost any system of haulage, and the one in question should lead to generalising slow speeds in descending steep gradients.

Greenwich Observatory.—This observatory is now being lighted by electricity. Mr. W. H. Christie, the astronomer royal, is establishing the plant in the south wing of the new physical observatory, now nearly completed, in the grounds. A gas-engine, dynamo, accumulators, and main leads are now on the premises, and the installation will shortly be finished. Any possible effect that the generation of electricity might have on the magnetographs within 170ft. will be guarded against by a triple iron shield completely enclosing the dynamo.

Auer Incandescent Gaslight.—There has been considerable discussion in Germany and Austria among gas and electrical engineers regarding the advantages of the Auer incandescent gaslight. The German Polytechnic Society has endeavoured to ascertain whether the Auer lamp could be used in a dusty and moist atmosphere. In reply to a request for an expression of opinion on the subject, the German Incandescent Lighting Company said that in places where dust was plentiful it was not advisable to employ the Auer system, because the dust deposited itself on the mantle, especially when the lamp was not alight, and the illuminating power diminished. Then, again, when the mantle is cold, it absorbs moisture, and becomes deformed, and its lighting power in this case is also reduced.

Liverpool University College.—The prospectus of the day classes in arts and science and of the evening lectures for the session 1893-94 has been issued. The electrical engineering course is intended to impart a thorough knowledge of the principles involved in electrical engineering and practical acquaintance with the use of machines and apparatus, and to be followed prior to a student entering works or office. The course, which extends over a period of three years, comprises much the same curriculum for the first and second years as that for civil and mechanical engineering, with the exception of additional hours spent in the physical and electrotechnical laboratories. In the third year a larger proportion of time is passed in the latter laboratory and in attendance at lectures and classes on electrotechnics. A course of 11 lectures will be given on telegraphy.

Heilmann Electric Locomotive.—Writing last week to Mr. B. H. Thwaite, Mr. C. Brown, of Basle, states: "It may interest you to hear that the big electric locomotive was started last Monday; it runs wonderfully sweet, the faster she goes the smoother, the disturbing influences of the reciprocating masses being entirely eliminated. No counterweights in driving wheels, but a steady tangential pull at the tires. This added to the compensating action of the compound bogies, combined, produce a locomotive which runs with phenomenal smoothness. You can hold a glass full of water, standing on the driving platform, without spilling a drop, or even producing a ripple on the surface. The movement is even less than in a first-class Pullman. It quite took the breath out of the railway engineers on the footboard; they could scarcely believe their eyes, their other senses failing to impress them that the engine was actually running."

Electro-chemical Effects on Magnetising Iron.—In the *Proceedings* of the Royal Society, Mr. T. Andrews draws attention to the electro-chemical effects on magnetising iron. From a long finely-polished rod, two steel bars were cut adjacently, so that they were practically alike in

general composition and structure. These bars were both weighed, and then immersed in equal quantities of cupric chloride solution, one of them having previously been magnetised. After a certain time (six to twenty four hours) they were taken out of the solution, freed from deposited copper and carbonaceous matter, then dried, and again weighed. It was found in every case that the magnetised bar had lost more in weight than the unmagnetised bar. For instance, an average of 29 experiments showed an increase of corrosion in the steel due to magnetic influence of about 3 per cent. under the conditions of experiment. It may be mentioned that the bars were not highly magnetised.

Electro-Chemistry.—Mr. G. H. Zahn has investigated the phenomenon of the separation of precipitates at the boundary of electrolytes, and has given the results in the *Ann. Phys. Chem.* The current was allowed to pass through two solutions of the same salt of different concentrations, from that of the greater to that of the less, a separation of the hydroxide of the metal then taking place at the boundary of the two solutions in certain cases. Such a separation was noticed with salts of magnesium, calcium, barium, strontium, aluminium, manganese, iron, zinc, and copper; but not in the case of silver salts. In the latter case, however, as also with the salts of sodium and potassium, which form soluble hydroxides, the presence of the hydroxides at the boundary between the solutions could be rendered evident by the alkaline reaction of the solution with methyl orange at this point. The author is inclined to regard the above phenomena as evidence that water plays some part in the electrolysis of salt solutions.

Manchester Central Station.—Referring to the note in our last issue as to when electric light would be available from the municipal station, we are informed by Mr. H. Wooter, electrician to the Corporation, that the supply has been at hand, and has been accepted by consumers for night service between 5 p.m. and 12 midnight, since July 31. On that occasion the Free Trade Hall was switched on, and on the following day the Bank of England, the Union Club, and several other places were lighted. Since then, our informant observes, a number of additional consumers has been connected each successive day, until at the present time an equivalent of 6,000 8-c.p. lamps and some arc lamps are joined to the mains, whilst current is also supplied for motive power purposes. The Corporation are, moreover, dealing as quickly as possible with contracts already signed for 10,000 additional 8-c.p. lamps, over 100 arc lamps, various fans, motors, and for cooking apparatus. The demand for current is so great that continuous running commenced on the 1st inst. There has not yet been any official ceremony, because the normal working conditions of the five-wire system will probably not be brought into operation until the end of the month.

Electric Railways.—The recent report of the committee appointed to frame clauses for insertion in the Bills promoted by electric railways, says *Engineering*, emphasises the well known fact that there is a large amount of leakage when the rails are used as conductors for the current. When only one rail is used for this purpose the leakage is into the earth, and thence along any pipes or wires that offer an easy path. When the rails are used as the positive and negative conductors respectively, the leakage becomes very much more serious, and, indeed, is practically prohibitive of this method of working. The columns of our contemporary have contained accounts of several attempts to avoid this difficulty by carrying the current in buried conductors and connecting short lengths of rail to these at intervals, so that the leakage is localised. A more recent method, proposed by Lord Alfred Spencer Churchill, is to make connections to the buried insulated conductor every 20ft. or so, and at each to erect a special contact-piece above the roadway. On the vehicle is a brush so long that it will always touch one of those contacts, and thus always be in communication with the main conductor.

Just the Same Here.—Over in the United States it has been found that the great demand for competent electrical engineers who can prove themselves reliable and skilful has led to a great rush of beginners and students into the field with an idea that their fortunes will thereby be made. Mr. G. D. Shepardson gives the following timely advice to such: "The work of most electrical engineers is largely something else with a little electrical work added. Many beginners are utterly unfitted to become engineers, having neither the ability, perseverance, or genius. They may succeed in becoming threshing-machine engineers, but they would better save the time and money spent in trying to become what they were never intended to be. Engineering involves a long and thorough training: one must have a taste and a talent in that direction; must possess the ability to perform a great deal of hard, unromantic work for 24 or even 60 hours at a stretch, carry heavy responsibility, control men, and manage work; do the work of three men at once when necessary, and be 'up early and always at it.'" Probably one-half the budding electrical engineers of this nation would make much better citizens and do more good in the world if they were to pool their modest capitals into some good electric light or power stations, and then shovel coal or collect tickets.

The Secret of Good Management.—The good time for electric traction is said to be coming in this country, and therefore it is fitting to suggest beforehand that the managers of electric tramways will need to be constantly striking a balance between improved services and reduced cost of repairs and maintenance. On one particular line of some considerable length and importance says Mr. Shepardson, the latter item is now reduced to a minimum by careful management. The number of me at one time engaged merely in rewinding armatures wa no less than 65' a preposterous feature to an English engineer's mind. However, they are now less than 20 in number, owing to the employment of men who are mechanics first and electricians afterwards. The motor men in charge of the cars on the line are furnished each with a book giving clear explanations of the various parts of the car and its equipment, illustrating and explaining, so far as is desirable, the object of each part. They are taught how to take proper care of the motors, and how to make ordinary repairs in case of accident on the road. Specially trained inspectors are also out on the line at all times to examine motors which do not work properly, and if anything is out of order they repair it at once or send it to the shop before worse follows. It is found that these inspectors save their salaries many times over.

Gas v. Darkness.—Our contemporary the *Journal of Gas Lighting* is the *beau ideal* of a biassed paper. We have never yet found it modest enough to ascribe any possibilities to electricity, but it has determinedly, year in and year out, sought and promulgated whatever in its estimation seemed most damaging to electricity and most worthy of praise in gas. It is constantly pointing out the danger of being left in darkness where electricity is used, and makes much of every fact of the kind it can muster. Its misfortune is that having so long and so constantly cried "Wolf," few pay the slightest attention to its cry—and why? In the instance we have specified light or dark, every-

body knows that gas plays pranks, and occasionally leaves its users in darkness. The electrical papers would lose all indication of fairness were they to collect and comment upon every gas failure and gas accident. Our contemporary can make merry over electric light failures at Hastings; why not at the same time give prominence to the gas failure at Holywell! Surely, what is sauce for the goose is sauce for the gander. We acknowledge our antagonism to gas as a dirty, stinking, dangerous material, and think we are benefiting the human race by advocating the adoption of a better system of lighting, utilising gas if you like, where a little dirt and stink is less harmful, in heating and in engines.

Electric Interlocking of Railway Signals.—Illustrated particulars have just been published relative to the Ramsay-Weir electrical interlocking apparatus, and from the *Railroad Gazette* we obtain the following details of these appliances—in use now for several years. The interlocking is effected by means of electrical contacts controlled by electric magnets, the contacts in their turn being governed by the positions of the signals and switches. On each signal-post for operating the arm or semaphore is a steel box which contains all the working parts. The principal item is a small electric motor, whose elongated shaft carries a pair of centrifugal arms and balls of a similar type to those employed on the old-fashioned steam-engine governor. It is the centrifugal force of these balls, acting through a lever when the motor is running at 2,500 revolutions a minute, which serves to pull the signal arm to "clear," the normal position being "danger," at which point the arm is held by a counterweight. Similar arrangements are used for moving the switches or points, the motion being given by a double ratchet-wheel and pawl with spiral spring release. The electric energy required to operate the system is obtained from a dynamo at a pressure of 125 volts. A small gasoline engine and a storage battery complete the equipment. To charge the latter for 24 hours requires the operation of engine and dynamo for about eight hours, and the engine takes to do this work from eight to ten gallons of gasoline, costing, say, 4d. a gallon.

Lightning Expresses.—We have received a pamphlet from Mr. F. B. Behr, Assoc.Inst.C.E., entitled "Lightning Express Railway Service: 120 to 150 miles per hour," and containing a mass of details, with illustrations of the system, which the author considers is the only one capable of being safely employed for passenger transit of a more rapid kind than that now available on our steam-driven expresses averaging a bare 50 miles per hour. Of course, the author proposes to employ electric energy for operating the lines, and thereby adopts the most reasonable method, avoiding all reciprocating motions. The permanent way for such a rapid transit line cannot, in his estimation, safely be of the ordinary type, where two rails are laid upon sleepers resting upon the ground. He, therefore, confines his plans to the use of an elevated and built-up structure (like that of the Lartigue single-rail system), the rolling-stock being balanced, as it were, on each side of the structure, and running upon one rail at the top. This method avoids all possibility of derailment at the high speeds named, and brings the centre of gravity below the point of support. So far as can be seen from the details given, the type of electric motors proposed to actuate the train consists of an annular armature bolted to each side of the bearing-wheel (and therefore acting direct), which revolves between bi-polar field magnets on each side, secured to the framework of the car. At 600 revolutions per minute the horse-power of each motor is stated to be about 50. Motors are mounted on all the carriage axles, no locomotive being thereby used at all. The current collector is an arm fixed to the carriage, and projecting into a channel which contains a bare conductor wire. The latter is lifted up by the collector, thereby making contact by its own weight.

The Lighting of Swiss Villages.—The typical English village is usually not lighted at all—at the utmost it will only have perhaps a score of gas lamps, and the majority of its inhabitants go to bed soon after sunset, or else use candles of 16 or more to the pound. Switzerland is the happy possessor of innumerable waterfalls, and it uses them for lighting up the valleys, which might otherwise appear always dark and gloomy. A good example of this may be seen in the famous Gruyère valley, where cheeses grow by the roadside (according to Mark Twain's agricultural editor). Here there are four or five small places—not one probably with more than 3,000 inhabitants—which are supplied with electric energy for lighting and other purposes from a well-equipped station operated by water power. At Bulle, where there is an available fall of 100ft., and a sufficient quantity of water to give 200 h.p., a single horizontal turbine, made by Faesch and Piccard, of Geneva, drives two 75-kilowatt alternators, one on each side, with exciters mounted on the same spindle, and running at a speed of 420 revolutions per minute. The current is generated at a voltage of 3,000, 10 per cent. loss being allowed over the line; the alternations are 49 per second only. The overhead line—of bare copper—traverses a distance of nearly six miles from the station, branching then for five-eighths of a mile and 1½ miles respectively to the ends of the circuit. Transformers reduce the voltage to 120 for the consumers' circuits. A few motors of the Alioth type, with rotary field, are employed in the village of Bulle.

Voltaic Cells with Fused Electrolytes.—In instituting a comparison of the observed E.M.F.'s of cells with their theoretical values, as given in "Thomson's law," the simpler the construction of the cell, the easier it is to ascertain the nature of the chemical action on which the calculation rests. In cells with aqueous electrolytes, according to Mr. J. Brown, the solvent introduces several irreducible complications arising from possible action of the solvent itself as an electrolyte, from the formation of insoluble films (either inactive and protective, as oxides, or active as hydrogen), or from the uncertainty of calculations involving heats of solution of the products of voltaic reaction. When the liquidity of the electrolyte is produced by fusion instead of by dissolution, these complications are to a large extent avoided; and as a matter of experiment, two fluid cells made up of metals, immersed each in its fused chloride, gives results nearer the "theoretical" values than those obtained with aqueous solutions. This is specially noticeable in the case of metals with high heats of oxidation, as, for example, magnesium and aluminium. The E.M.F. of cells containing pairs of the metals tin, lead, and zinc come out nearest to the theoretical values. The other metals which were tried did not give so close an agreement, but could be brought into agreement by applying constant corrections, one for each metal; and reasons are given by Mr. Brown for attributing these corrections to the high temperatures of the cells, as compared with the temperatures for which the recognised heats of combination are true. Four of the cells were tested by passing currents through them in both directions alternately, and noting the E.M.F. after the passage of each current. Polarisation was observed in the case of zinc-silver, but in the others it was practically absent.

The Nutting Arc Lamp.—Of newly invented arc lamps, and mechanisms for them, there is indeed no end; every week the technical papers seem to unearth a fresh one—fresh, that is, so far as the name and minor details are concerned. Most have a strong family likeness to one another; and yet, in spite—or, perhaps, rather because—of the incessant competition, the old-established lamp-makers get nearly all the trade. None of them are perfect, however; though if only the good points of all could be combined in one we should expect to get a satisfactory lamp. An ingenious and perhaps genuine improvement is that which characterises the Nutting arc lamp; in this the feeding mechanism consists of a ring of waxlike material, 2½in. diameter, mounted between two ebonite discs on a shaft which is geared directly to the upper carbon rod. A metal pin is mounted on a stationary holder in such a manner as to have one end embedded in the surface of the wax to the extent of ⅛in. or $\frac{3}{16}$in., the cross-sectional area of the ring being about ½in. square. On the other end of the pin is wound a fine German-silver wire resistance equal to about 150 ohms; and this, together with an additional resistance of about 600 ohms, forms the shunt or feeding circuit of the lamp. When the pin is embedded in the wax, the upper carbon rod is held rigidly in place, but on the carbon points separating the shunt circuit will at once take its share of current, the proportion varying with the voltage of the terminals of the lamp, or the carbon points. The metal pin at once becomes heated by the passage of the current through the resistance wire wound upon it; and as it heats it warms and tends to melt the waxlike material in which its end is embedded, thus allowing the ring to slowly revolve and feed the carbon to the proper length. The hot wax at once solidifies behind the pin, leaving a smooth and even surface for the next revolution. Of course an adjustment is provided to allow for extreme change of temperature.

Scientific Papers.—Some discussion is taking place, principally among the members of the Physical Society, with reference to the publication of papers. The subdivision of societies, each with its own "journal of proceedings," issued to a strictly limited *clientele*, has made it difficult for workers to keep in touch with their work, and there is no doubt, says the *Pall Mall Gazette*, that a vast amount of valuable time is being wasted in doing and re-doing work which has already been done, and the details of which are accessible in print if only there existed some suitable system of reference. The want of such a system is growing more and more pronounced, and various solutions of the difficulty have been proposed. One is the formation of a national bureau, in which all current technical literature should be classified and indexed under the different branches of science. Another is that the method of publication should be revised. Mr. A. P. Trotter suggests that the method of publication adopted by the Physical Society is the most free from objection, and that for physics papers the society might well be made a basis of centralisation. The more elaborate and important papers would still go, as they do now, to the Royal Society, whose *Proceedings* are, however, costly, and not very widely read; mathematical papers could appear in the *Philosophical Magazine*, which at present, by arrangement, publishes most of the Physical Society's papers in duplicate; and the physics papers, pure and simple, which represent the work carried on from day to day by the leading professors and experimenters, could be dealt with by the society all the year round. Most people, observes our contemporary, are agreed that some arrangement will shortly have to be made whereby rivalry among the older and younger societies will be avoided and a wider circulation obtained. In America, where the same difficulty has been found to exist, a move has been made in the direction of centralisation. Mr. J. F. James describes the foundation of an institution called the Scientific Alliance of New York, the chief object of which is the establishment of a centre where knowledge of what is done in one society is conveyed to all the rest. The Alliance is not a year old yet, but is already in a fair way of doing good work.

The Government and Telephony.—The telephone question is becoming rather acute. So far, nothing that has been said has induced the Postmaster-General to divulge the terms of the agreement that will shortly be signed with the National Telephone Company. Replying to Captain M'Calmont on Monday, Mr. Arnold Morley said the Postal Department had determined to make it a condition of any new telephone licenses that the system should be constructed entirely of twin circuits, so that there might be an assurance of efficiency, as the present system of a single wire with an earth return was at present causing great dissatisfaction in some large cities. Questioned by Mr. A. O'Connor as to whether the policy of the Department was that no new licenses would be granted unless with the consent of corporations and municipal authorities, the Postmaster-General referred to the Treasury minute laid before the House of Commons on May 27, 1892, as follows: "For a license to establish an exchange in a particular town no application will be entertained unless a formal resolution in its favour has been passed by the corporation or other municipal authority, and evidence given that there is sufficient capital subscribed to carry out the undertaking." In one case a resolution of this kind qualified by conditions had been conveyed to him by the applicant for a license. The telephone companies possessed no statutory powers. Application for a license had been made by the Corporation of Glasgow. Replying to Mr. Henniker Heaton and Mr. Cayzer, Mr. Morley explained that it was not proposed to confer a new license on the National Telephone Company; the date for the termination of their license was December 31, 1911, and that date would remain undisturbed. So also would the freedom they at present exercised in fixing their charges for telephone exchange wires. The main object of the new agreement was the purchase of the trunk lines and the consequent withdrawal of the right of the company to erect and work such lines. As to the submission of the agreement to Parliament, he referred to previous answers that the agreement would be placed before them when completed (answers on July 31 and the 18th and 31st ult.). It is stated that the question of municipal telephones will again be raised in Parliament, and a statement on the subject has been circulated amongst members of the House of Commons. With regard to the same question, Captain Bagot, M.P., intends to ask the Postmaster-General to-day, "Whether, in view of the fact that the report of the Select Committee on the Telegraphs Bill, on which the agreement between the Post Office and the National Telephone Company is to be founded, was arrived at without any evidence being taken either from any municipal corporation or from any representative of the telephone-using public, he will consider the advisability of reappointing a select committee to take further evidence, in the interests of the public or the corporations, on the subject, before concluding the agreement with the National Telephone Company." We give in another column a copy of the circular issued by the Glasgow Corporation on the telephone question, and as the subject is of such immediate interest we have no hesitation in reproducing from the *Times* of yesterday the article printed on another page.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC.MEM.INST. ELECTRICAL ENGINEERS.

(Continued from page 175.)

DISTRIBUTION OF ELECTRIC POWER.

The word "system" used in connection with the generation and distribution of electric power, is as much misused as that other unfortunate word, "accumulator." A "secondary battery" no more accumulates electricity than a machine gives out more energy than is put into it. The electric energy put into it simply produces certain chemical reactions, and so the electric energy is converted into chemical energy, which latter can be reconverted back into electric energy again when wanted by allowing the plates to regain their original chemical condition. But there is no "accumulation" going on; in fact, it is rather the reverse, seeing that there is a dead loss of above 25 per cent of the electric energy put into the cells. When the electric light was first exploited, in the days of the mania of 1882, everything electrical was somebody's "system," every arc lamp or dynamo put upon the market was called some system or other of electric lighting, and since the bulk of them were dismal failures, the word got bad repute. No particular piece of apparatus constitutes a system, whether patented or not. Furthermore, the dynamo was only invented once, crude, at first, certainly, but gradually improved first in one way, then in another. Then various well-defined types were evolved, as drum, disc, and ring armatures, horseshoe, double horseshoe, and multipolar field magnets, series, shunt, and compound winding. By merely collecting the current we obtained alternating currents of electricity; afterwards, inventive minds added the commutator, and this gave us continuous currents of electricity. Finally, coming close to the present time, two or more pairs of separate collecting rings were keyed on the shaft, each pair being connected to so many of the armature bars, and thus we obtained two, three, or multiphase alternating currents. Again, the question of pressure was determined by the thickness and number of armature wires or bars – armatures wound with a great number of thin wires giving high pressure currents, say at 1,000 volts, those wound with a few thick turns giving low-pressure currents, say at 100 volts. Dynamos are not invented nowadays: like steam-engines they are designed, each dynamo builder having his own ideas of details of construction, the data for the same having been collected by experience and actual experimental tests, obtained at a great cost of time and money, in many cases a score of differently-designed parts being tried and condemned before the right one is found.

Broadly speaking, there are two chief and entirely distinct methods of supplying and distributing electric power, and which may with truth be called "Systems." These are (1) the Low Pressure Continuous-Current System, and (2) the High-Pressure Alternating-Current System.

Low-Pressure System.— We will deal with this system first, as it is of less importance than the other. Low-pressure currents can only be used to distribute electric power over very limited areas, the reason being that when electricity is distributed at a certain pressure from some central source there always must be a gradual fall of pressure through the distributing mains, and this fall of pressure becomes greater and greater as the distance from the source increases. A system of water service affords an exact analogy, as the pressure of the water becomes less the farther it travels from its supply source. From this it is evident that the fall of pressure will have a serious effect on the lamps. In the last article but one, it was shown in Tabulation 24 that a slight fall of pressure of only 4 per cent. causes an enormous loss of light, as much as 25 per cent., so that while the lamps that are close by the source of generation burn brightly, and at their normal candle-power, the lamps will burn dimmer and dimmer as their position becomes farther away from this source. A fall of pressure being therefore inevitable, the best thing to do is to try to reduce this fall as much as possible. By Ohm's law we know that the fall of pressure along a wire is represented by the number of volts necessary to force a certain current through a certain resistance in ohms. Five hundred amperes flowing through a main cable 500 yards long and 1in. diameter, and having a resistance of ·16 ohm, will signify a fall of pressure at the farther end of ·16 × 500 = 8 volts. The current density here being about 636 amperes per square inch, but this is only for one cable. The return cable must also be reckoned. This gives us a total drop of 16 volts, which is absorbed in sending the current through the cable—eight in the positive cable, and eight in the negative; so that if the working pressure at the source be 100 volts, and a lamp be fixed 500 yards away, connected to the end of this cable, it will only receive 74 volts at its terminals, and naturally will be useless for illuminating purpose. This example will give an idea how great is the loss of pressure when heavy currents have to be carried any considerable distance.

There are several methods in use by which the low-pressure system is enabled to supply larger and more extended areas, such as by the adoption of what are called "feeders," the three-wire system, the five-wire system, etc., all these being added to the simple parallel system. The simple parallel system consists, as its name implies, of a pair of mains or a number of pairs, radiating out in various directions from the generating source, the sub-mains and branch wires being tapped off along the route; and since incandescent lamps only take a pressure of 110 volts at the most, therefore the pressure at the generating station must be that, or, say, two or three volts more, in order to allow for the drop of pressure along the mains. Suppose the station pressure is 112 volts when the full load is on, and that there is a total fall of four volts between the station and the farthest lamp burning; now, when the load lightens and becomes, say, one-half of the full load, this fall of pressure will be only two volts, because the current density in the distributing mains is only one-half of what it was before, and hence the pressure required at the station will now be 111 volts. This variation of pressure can easily be obtained by a rheostat in the field of the dynamo, or else by varying the speed of the engine. A simple parallel system like this is of very little use in distributing electrical power from central stations, because the area it would supply would be too limited in extent; at the outside, it could only be used for a radius of 200 yards. This distance is no more than would be suitable for a large manufactory or block of houses where a private plant is put down. The distance that a certain current can be carried for a fixed percentage of fall of pressure depends on the current density employed in the mains; when the density is high the distance is short, and when low the distance is long. The resistance of the mains is constant in value whatever the current may be, so that as the current increases in the main it requires more pressure to force it through this resistance. We arrive, then, at this rule:

Distance is inversely ∝ current density.

This applies when the pressure at the source is constant in value, as it would be in any parallel system of distribution. The following distances in yards have been calculated out to show various percentages of fall of pressure for various current densities per square inch sectional area of copper main.

TABULATION 28. – Percentage of Fall in Pressure.

Current density.	½ %	1 %	1½ %	2 %	2½ %	3 %	3½ %	4 %
300	33	66	100	133	166	200	233	266
400	25	50	75	100	125	150	175	200
500	20	40	60	80	100	120	140	160
600	[illegible]	33	50	66	83	100	116	133
700	15	30	43	57	70	85	100	114
800	12	25	37	50	62	75	87	100
900	11	22	33	44	55	66	78	89
1,000	10	20	30	40	50	60	70	80
1,100	9	18	27	36	45	54	63	72
1,200	7	15	22	30	37	45	58	66

The range of fall of pressure is from 1 to 4 per cent. The distance in yards signifies the actual distance of the lamp from the source of generation, and hence the fall of pressure is along a length of cable equal to twice this distance, because the length of both positive and negative cable must

be taken into account. Taking the greatest distance shown—namely, that of 266 yards—there is here a fall of 4 per cent., so that if 100 volts were given at the dynamo, only 96 would be received by the farthest lamp, fixed 266 yards away, and this is with an extremely low current density of 300 amperes per square inch. To employ such a low density would mean that an enormous weight of copper would be sunk in mains and branch mains, and the expense of this mass of copper would be extremely great. To attempt to carry these mains any farther away would make the fall of pressure so much that the lighting would be perfectly worthless, because if the fall of pressure was doubled, and made 8 per cent., it would only give a working radius of 532 yards, and so it is clear that it is practically impossible to distribute power over any wide areas, like a town of five or six square miles, by using a simple parallel low-pressure current of only 100 or so volts.

(To be continued.)

PATIN FLYWHEEL ALTERNATOR.

(Concluded from page 209.)

As complement to the flywheel alternator, M. Patin has constructed a type of transformer very noticeable for its high efficiency and its low absorption of current at no load

This transformer is of the closed magnetic circuit type. It is of the form of a rectangular parallelopiped, Figs. 10 and 11. The coils of the secondary circuit are placed upon

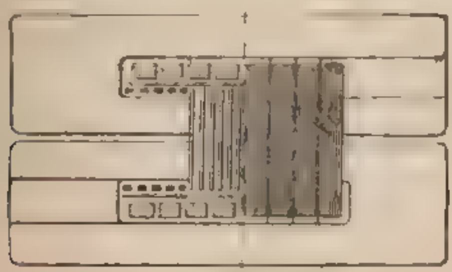


Fig. 10.—Patin Transformer.

the iron; the primary circuit is composed of eight coils in the form of tubes of rectangular section: these are insulated from each other in addition to the insulation of each turn of wire. The magnetic circuit is also constituted by two kinds of tubes of rectangular section, placed parallel to

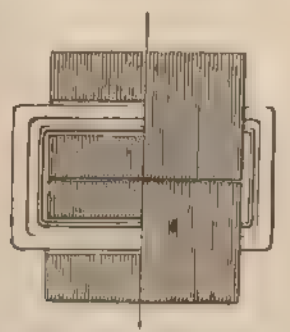


Fig. 11.—Patin Transformer.

each other on their largest side. Each of these is composed of soft Swedish iron plates, carefully laminated and cut to measure, and covered with paper on one side. These iron sheets are stamped in the form of the letter U with right angles, so as to give the least possible amount of waste pieces. These latter, moreover, are utilised in the construction of the small transformers which are used for test lamps in the central stations.

The iron sheets are arranged in pairs, with their metallic sides touching. A sufficient number are laid together, and the edges are then slightly rounded. This system, allowing easy putting together or repair, gives a very low magnetic resistance.

The sheets are compressed between two cast-iron frame plates bolted securely together, each having two cavities, in which are placed two porcelain bases, which carry the gunmetal terminals of the primary and secondary circuits.

The efficiency at full load is very high, and is hardly ever less than 98 per cent.; the absorption at no load is extremely low, and barely reaches 2 per cent. The following table gives the figures of two Patin transformers of 4,000, Fig. 12, and 8,000 watts, Fig. 13, respectively.

Capacity of transformer.	4,000 watts.		8,000 watts.	
	Primary	Secondary	Primary	Secondary
Voltage ...	2,400	100	2,400	100
Turns of wire	1 080	45	720	30
Size of wire	16 10	3 × 43/10*	20 10	6 × 40/10*
Length of wire	880m	29 5m.	—	—
Thickness of iron sheets	5/10		5/10	
Section of iron ...	180cm.^{2}		—	
Loss	12 volt	0 5 volt	12 volt	0 5 volt
Efficiency ...	96 per cent.		66 per cent.	

* In parallel.

The frequencies may be varied between 50 to 83.

We may conclude this description of the Patin system with the following results obtained with the flywheel alternators in two installations of very different size, driven by different types of engines.

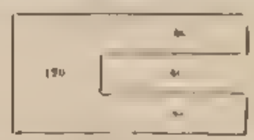


Fig. 12.—Sheet for 4,000-watt Transformer.

The first was driven by a turbine furnished with a Faesch and Piccard regulator; and the second by horizontal steam-engine with variable cut-out of the Blondel system (illustrated last week); the variation of voltage when the load is thrown suddenly off is less than 2 per cent.

Capacity in watts	40,000	120,000
Volts at terminals	2,400	2,400
Current at full load—amperes	16·7	50
Resistance of armature—ohms	4·5	0 96
Number of field coils	24	104
Resistance of fields—ohms ...	4·8	2·5
Number of armature coils.. ...	24	104
Revolutions per minute	300	95
Frequency	60	82
Efficiency	94	96
Exciting energy—watts	1,200	2,400

The expenditure of watts for excitation of field is included in the calculation of efficiency.

The Patin flywheel alternator, of which an illustration has been given, now at work in the workshops of M. E. Boyer, is of considerably higher capacity than the Blondel engine used to drive it, so that the efficiency given is less than it should be if engine and dynamo were of the same power.

Fig. 13.—Sheet for 8,000-watt Transformer.

The engine has a piston 0·360 metre diameter, 0·700 in stroke, speed 80 revolutions per minute. According to indicator diagrams taken, the engine running light absorbs 6·2 h.p. (the provisional installation does not include condensers). The engine will supply 280 16-c.p. lamps, indicating 30·3 h.p., and 380 lamps 16 c.p., for 38·6 h.p., or about 12 lamps of 16 c.p. per indicated horse-power.

The efficiency of the engine is 87 per cent., of the dynamo 94·2 per cent. The illumination is steady and brilliant whatever number of lamps are lighted.

It may be added to the above description of his dynamo that M. Patin is now carrying out tests with a dynamo for transmitting power by alternating currents, and that very important results in this direction have been already obtained.

WORLD'S FAIR ELECTRICAL PLANT.*

BY R. H. PIERCE.

(Concluded from page 210.)

Distribution of Arc Lighting.—Having indicated the general arrangement in Table A, I will describe as briefly as possible the plant, taking up the different kinds of service in order. For the purpose of description, we will divide all the dynamo-electric machines into two classes. First, exposition dynamos, or machines furnishing service to the exposition and operated by the electrical engineering department; secondly, exhibit dynamos, or machines furnishing current to exhibitors in Electricity Building and operated by the various electrical companies which furnish them as exhibits. The arc light plant comprises the following machines:

	Dynamos.	Lights each.	Total lights.
Western Electric plant	10 exposition	50	500
	2 exhibit	50	100
Thomson Houston plant	27 exposition	50	1,350
Excelsior plant	6 exposition	50	300
Standard plant	22 exposition	50	1,100
Fort Wayne plant	13 exposition	60	780
	1 exhibit	60	140
	1 "	80	
Brush plant	12 exposition	60	720
	4 exhibit	60	240

having an insulation of ⅛in. Para rubber compound, a part having mechanical protection of lead, and the remainder being protected by two tapes wound in reverse. Ninety miles of this wire is used. The circuits in the main subway and in buildings are of No. 8 B.W.G. safety wire, having a covering of 74 mils thickness of rubber and braided. Of this wire there are about 200 miles.

All arc lamps are furnished with opalescent or opal globes. This, of course, materially reduces the candle-power, but by diffusing the light undoubtedly gives much more uniform and satisfactory lighting than could be obtained by clear or ground globes. The general style of construction in the buildings consists in suspending the lamps from a No. 9 W. & M. iron wire, the conductors being run from lamp to lamp in the air. The lamps are attached to hangers which are insulated both from the lamps and the line. This method of construction has the advantage of using the minimum amount of wire and doing away with all unsightly loops. It is quickly and cheaply put up and presents a neat mechanical appearance. The lamps on posts and over the aisles in buildings are trimmed with step ladders, except in Machinery Hall, where they are trimmed from travelling cranes. In certain cases where the lamps are hung in inaccessible places, a special form of hanger is used, so that by pulling a cord the lamp can be disconnected from the circuit and dropped to any desired height, and again pulled into place, without interrupting the circuit. The device also does away with the use of any slack wire.

TABLE A.

Building.	Main Floor.			Gallery.			Total lights inside.	Average square feet per light.	Loggia and court lights.	Total number lights.	Remarks.
	Number lights.	Square feet per light.	Distance apart.	Number lights.	Square feet per light.	Distance apart.					
Machinery	238	1,497	25	—	—	—	—	—	—	—	
" Annex	173	1,516	25	—	—		411	1,505	26 Loggia	437	-
Horticultural dome	37	1,113	24	36	856	28	—		-	-	—
" curtains	52	815	25	—	—	—	200	951	17 Courts	217	-
" pavilions	48	1,197	34	27	1,049	30	—		-		—
Anthropological	55	1,886	35	32	1,499	38	87	1,743	-	87	
Manufactures	389	1,687	30	314	1,828	40		-	-	—	—
" coronas	414	1,048	-	-	—	—	1,117	1,499	70 Loggia	1,187	—
Agriculture	202	1,826	30	165	1,345	40	—	-	—	—	—
" Annex	81	2,022	50	—	—	—	448	1,684	16 Loggia	464	—
Mines	113	1,998	30	64	1,904	40	177	1,964	8	185	—
Fisheries	28	2,132	40	14	1,446	40	49	—	—	49	-
" W. Pavilion	7	1,954	45	—	—	-	—	1,910	—	—	—
Illinois State	33	1,421	25	39	445	40	72	898	6	78	
Transportation	181	1,346	33	130	1,230	32	311	1,298	6	—	—
" Annex	149	2,445	45	—	-	—	149	2,445	Clere	466	Helios arc.
Leather	48	1,470	45	31	1,669	41	79	1,712	—	79	—
Forestry	59	1,483	35	—	—	—	59	1,483	—	59	—
Totals and average for main buildings	—	—	-		—	—	3,159	1,544	149	3,308	—
Miscellaneous buildings	—	—	—	—	—	—	—	—	—	18	—
Total lights in buildings	—	—	—	—	—	-	—	-	—	3,426	—
Total inside area	—	—	—	—	—	-	-	-	—	—	4,877,905 sq. ft.

There are therefore 90 exposition dynamos, having a total capacity of 4,750 lights, and seven exhibit dynamos, having a total capacity of 480 lights, or a grand total of 99 dynamos, having a total capacity of producing 5,230 lights, all of 2,000 nominal candle-power. All these dynamos are regular direct-current series machines, and are equipped with standard switchboards and appliances of the respective systems.

In addition to the foregoing, there are in the terminal station 160 six-ampere arc lamps, and 228 three-ampere lamps, equivalent to 164 lamps of 2,000 nominal candle-power. There are also 351 Helios arc lamps attached to the incandescent circuits, most of these furnishing lights to exhibitors and to the concessionaires in the Midway Plaisance. The grounds are lighted by 1,421 lamps, of which 1,308 are upon ornamental iron lampposts, and the remainder, which light the fences and the south grounds, upon 40ft. wooden poles.

The grand total of all arc lamps in the plant at the present time is equivalent to 5,362 lamps of 2,000 nominal candle power. The outside circuits are all carried underground, excepting those south of Machinery Hall and along the fences. In the duct trunk line and in all underground ducts, the conductors are of No. 8 B.W.G. rubber covered safety wire,

The grounds and all the buildings are supplied with two entirely independent circuits. One set of evening circuits has single-carbon lamps, calculated to burn from dark to the closing hours of the night. The other set of circuits, which comprise about 10 per cent. of all the lighting on the grounds, is used for patrol, or all-night lighting.

The feature of the arc lighting is undoubtedly the lighting of the central nave of Manufactures Building. Here the lights are suspended from five great fixtures or coronas. The space to be lighted is 1,268ft. long and 368ft. wide. The coronas are suspended 140ft. from the floor. The central corona is 75ft. in diameter and carries 102 lamps. The other four coronas, which are equally distributed along the main longitudinal axis of the building, are 60ft. in diameter and carry 78 lights each, making a total of 414 lamps. The coronas, which are made of angle iron, are circular hanging galleries in which the trimmer can walk from lamp to lamp. They are reached by iron ladders from the trusses above. The great arched roof of the building acts as a reflector for the lamps, and the lighting, as it appears to the eye, is absolutely uniform.

Search lights. — There are at present installed four Schuckert search-lights on the four corners of the Manufactures Building. These lamps are operated from the 180 kilowatt 120-volt Siemens dynamo in the British section in Machinery Hall. Two lamps are of 150 amperes, one of 100 amperes, and one of 60 amperes. The diameters are respectively 60in. 44in., 36in., and 24in. The 60in. lamp on the north-west corner is the largest and most powerful ever built, and gives a beam having an intensity of 194,000,000 c.p.

Incandescent Plant.—All but a small portion of the incandescent lighting of the exposition is supplied from the Westinghouse plant. This plant comprises 12 10,000 light dynamos, six of which are directly connected to 1,000 h.p. engines and six are belt driven, and two 4,000 light dynamos, also belt driven. All these dynamos furnish a current of 2,200 volts E.M.F., and are compound wound. Each 4,000 light machine has its own exciter, but the 12 10,000 lighters have their fields excited by three 100-h p. exciters, which are operated in multiple arc. These machines are all connected to an immense switchboard, which is the most striking object in the electrical plant. This switchboard, which is of white marble, is arranged in two storeys or sections. The lower, or dynamo-board, controls all the dynamos. Each large alternator is a double machine having two independent armatures, so that the board practically has connections for 26 alternators and five exciters. The three large exciters, which are compound wound for 250 volts, are connected to a three-bar 'bus system, which feeds the fields of all the large dynamos. The second storey of the board is the circuit-board, carrying instruments and switches for 40 circuits or feeders, and the whole system is so arranged that any dynamo can be connected to supply current to any of the 40 feeders. The 12 large machines are wound for only 7,200 alternations per minute, thus supplying current which can be used with perfect success in supplying arc lights. Each large machine, as before stated, has two independent armatures. These armatures are so connected that the two circuits from each dynamo carry current differing in phase by 90deg., so that any of the large machines may be used to furnish current for operating either incandescent or arc lamps, or two-phase motors. The distribution of incandescent lighting is shown in the following table :

EXPOSITION LIGHTING.

Lighting Inside of Buildings.

	Lights.
Administration	2,949
Agriculture	728
Music Hall, Casino, and Peristyle	4,122
Gallery Fine Arts and Annexes	17,774
Manufactures	1,113
Machinery Hall and Annex	1,772
Woman's	3,272
Miscellaneous	6,064
Total inside lights	37,794
Exterior or Decorative Lighting.	
Basin and bridges	2,331
Cornice and dome of Administration	2,049
Other cornices	3,786
Grand total exposition lights	45,960
Contract Lighting.	
Buildings of states and governments	4 881
Buildings of concessionaires and exhibitors in Midway Plaisance	5,416
Buildings of concessionaires and exhibitors in Jackson Park	1,947
Exhibitors and concessionaires in exposition buildings	7,468
Total contract lighting	19,712
Grand total	65,672

The circuits or feeders are calculated for a loss not to exceed 10 per cent., each circuit being provided with a Stillwell regulator capable of increasing or decreasing the initial pressure on a circuit 5 per cent. All circuits, excepting one to the south grounds, are run entirely under ground The cables, from the switchboard to converters, are all duplex Waring cables, except in the main subway, where Grimshaw rubber-covered wire is run on insulators. All converters are placed in fire and waterproof pits just outside the buildings, and the secondary wires are led into the buildings in vitrified tile duct. The largest converter used has a capacity of 200 lights, and nearly all are of that size. Every converter on the ground has its own independent secondary circuit, so that no trouble upon a secondary or inside circuit could ever put out more than 200 lights. The secondary wiring is controlled in all cases by switches and cut-outs located at points where wires enter the buildings, and the circuits are, in general, distributed from asbestos-lined boxes in which the cut-outs and switches are bunched at centres of distribution. The inside wiring is done entirely with the best grade of Grimshaw rubber-covered and taped wire, and the wires are run almost entirely in standard moulding or in interior conduit. The lamps, which are of 105 volts, are all the new stopper lamp of the Westinghouse Company. The general standard of the exposition lighting for lamps suspended at the ordinary height from the floor is 40 square feet of floor surface per 16-c.p. lamp, but inasmuch as the plant presents almost every variety of an incandescent lighting problem that can be thought of, the intensity of lighting varies greatly, ranging from 18½ square feet per 16-c.p. lamp in the Gallery of Fine Arts, and 7½ square feet per 16-c.p. lamp in the smallest gallery, to 3,700 square feet per 16-c.p. lamp for the system of patrol lighting under the floor of the Manufactures Building. The most novel lighting is the lighting of the tanks in the Fisheries Building, the aquaria being lighted only by invisible lights shining through the water of the tank. The most brilliant lighting is the lighting of the Gallery of Fine Arts, where the lamps are placed in reflecting screens around all sides of each picture gallery, the lights being only 8in. from socket to socket for nearly two miles of screens. The finest lighting is undoubtedly that of the Administration Building. The lighting of the interior is wonderfully uniform, and, in conjunction with the exterior decorative lighting, forms probably the most difficult and beautiful piece of incandescent lighting ever executed. In the incandescent lighting of the exposition it has been the aim throughout to avoid display lighting, but to secure sufficient and uniform illumination, and, where the lights have been placed for decorative effects, to place them so as to be inconspicuous by day, and to bring out at night the decoration or lines of the buildings. Wall sockets have been largely used, and stiff pendant fixtures have been used, but in one building simple clusters hung from flexible cord being almost universally used. This method of construction proves very satisfactory, and has the advantage of being easily and quickly installed, so as to always present a mechanical appearance. It is easily maintained, and, what is important in an exposition, the position of the lights can be easily and quickly changed without disfiguring or damaging the ceiling.

In addition to this lighting, the Siemens and Halske Company, of Berlin, has installed the following incandescent lights : Wooded Island, 120, 25 c.p. ; Choral Hall, 1,740 lights, equivalent to 2,462 lamps of 16 c.p. ; terminal station, 567 lamps, 16 c.p., being equivalent in all to 3,117 lamps of 16 c p. This makes a total of all incandescent lamps of equivalent of 68,789 lamps of 16 c.p. The Siemens and Halske lights are operated from a generator in the German section, Machinery Hall, having a capacity of 700 kilowatts, and furnishing current to the light mains of 440 volts. The lamps upon Wooded Island are operated in series of four, and incandescent lamps in the buildings are operated upon a five-wire system with equalising motors at the centres of distribution. The feeders are of armoured cable laid direct in the ground. This plant is interesting as illustrating the difference between European and American practices, and is the only plant of its kind in practical operation in this country.

Power.—Although the electric lighting has been carried out on a scale never before approached in an exposition, it is in the transmission of power that the advance of the art of electricity is most conspicuously shown. With the exception of the power in Machinery Hall, and a portion of the power in the Mines and Mining Building, all the power which is transmitted from the great power plant is transmitted by electricity, and even in Machinery Hall al

operates the great cranes, the elevators, and a part of the main-line shafting. Circuits are so arranged that power can be had in any building and in any portion of the grounds. The generating plant in Machinery Hall comprises the machines shown in the following table:

GENERATORS.

	Make.	No. of gen.	KW.	Voltage	Total KW.	
Exposition:	Mather	2	225	550	450	
	Mather	2	120	550	240	
	"C. & C."	4	80	550	320	
	"C. & C."	2	80	250	160	
	Eddy	4	186½	550	746	
	Westinghouse	1	373	550	373	
						2,289 kilowatts.
Exhibitors:	National	1	80	500	80	
	Jenney	1	40	500	40	
	Western Electric	2	137½	250	275	
	Wood	1	120	500	120	
						515 kilowatts.
	Grand total					2,804 kilowatts.

Making a total generating capacity of 2,289 kilowatts, or 3,070 e.h.p., for exposition use, and 515 kilowatts, or 690 e.h.p., for exhibitors' use—a grand total generating capacity of 2,804 kilowatts, or 3,585 e.h.p. All the generators, except two 80-kilowatt machines, which supply the power for the elevators in Administration Building, are regular street railway generators, wound for 500 volts, with a guaranteed E.M.F. of 550 volts at full load. Each type of machine has its own independent switchboard, but relay circuits are run between boards, so that in case of emergency the feeders from one board can be fed from the generators of another. The circuits are run in the main subway and upon the structure of the elevated railway. The feeders and mains consume 180,000ft. of No. 0000 wire, B. & S. gauge, 19,000ft. No. 000 B. & S. wire, 12,000ft. No. 0 B. & S. gauge, and 24,000ft. No. 1 B. & S. wire. This is exclusive of the distributing mains running to the various motors. All the wire is rubber covered and braided, the No. 1 wire having $\frac{3}{32}$in. thickness of rubber, and the larger sizes are covered with ⅛in. thickness of rubber. The cable is of the make known as the E. M. W. The motors used by the Exposition Company are all supplied by the General Electric Company, with the exception of two 150 h.p. Westinghouse motors operating shafting in the Mines and Mining Building. Exhibitors provide their own motors of such type as they wish. The applications of electric power are almost universal, as electric motors are used to operate almost every kind of machine in use by the exposition, or displayed by exhibitors. The distribution of light and power as shown in the tables is exclusive of the electric power consumed in the Electricity Building. This building consumes all the electricity generated by the machines designated as exhibit machines, the electricity being used for light, heat, and power, and for producing the many electrical effects displayed in the Electricity Building.

Electric Launches and Electric Fountains.—The four 150-kilowatt Edison dynamos furnish current for operating the electric fountains in the evening, and for charging the storage batteries of the electric launches after 10 o'clock at night. Each fountain is illuminated with 19 80-ampere Knowles arc lamps, requiring in all 300 kilowatts, or 400 e.h.p. The launches, 58 in all, are each equipped with a motor of 4 h.p., operated by a storage battery of 78 cells. The circuits of both fountains and launches are of Edison underground tubing, and are arranged as a three-wire system.

Intramural Railway.—Although it is not a part of the plant in Machinery Hall, a description of the electric plant would not be complete without a reference to the electric intramural railway. This road is the finest elevated electric railway ever constructed. The station has a generating capacity of 3,700 kilowatts, or 5,000 e.h.p., including the largest railway generator in the world, rated at 1,500 kilowatts, or 2,000 e.h.p. The road has 6¼ miles of single track, and is installed with a third rail system. The cars are regularly run in trains of four, each having a capacity of 133 h.p., with a speed of 25 miles an hour.

Installation Rules and Inspection.—The installation of the electrical plant throughout has been carried out according to the rules known as the national code, which was accepted as the standard by the insurance auxiliary committee. This code has been made part and parcel of all specifications and contracts. More than ordinary care has been exercised in inspection. Each large building has had a special inspector, as well as each principal branch of the work. Working plans were made showing the location of every lamp, either arc or incandescent, except where lights were located in exhibitors' spaces or pavilions of which detailed plans could not be obtained, and in these cases the plans show circuits up to the cut-outs in exhibitors' spaces. The contractors for incandescent lighting were required to submit for approval, in all cases, working plans showing details of cut-out boxes, and arrangement of circuits, showing each light, and having marked in figures the length of each circuit and the gauge of the wire. Four prints were made of each plan, the contractor and exposition each keeping one print as a record, the third print being given to the foreman of the contractor as a working plan, and the fourth being given to the Exposition Company's inspector, whose duty it was to see that the work was installed according to the plan and national code, and in a workmanlike manner. Although the making of complete wiring plans has apparently never been considered necessary by architects, it was found to be the only way in which a work of this magnitude and variety could be thoroughly inspected, and the results obtained were most satisfactory. The inside wiring almost always tested out perfectly clear, with very high insulation, and when the lights were thrown out by thousands for the first time, the inside wiring was almost absolutely free from "bugs," and if there were any they were so easily removed that their presence was never noticed.

Much that would be of interest cannot yet be written, for the efficiency of the various machines is yet to be determined by tests, and the length of this paper does not admit of going into details of construction; but I will conclude by enumerating a few points to which I would especially direct the attention of such as may wish to draw conclusions from the inspection of the electric plant.

1. The great saving of space to be made by the use of the direct-coupled dynamo.
2. The advantage of the adoption of a central-station system having machines of one type, and large units suitable for supplying both arc and incandescent lights and power service from the same conductors.
3. The advantages in series arc wiring of construction and devices which do away with slack wire, and admit of more mechanical construction and a neater appearance than is generally obtained in this class of work.
4. The possibility of, in all cases, doing mechanical work and at the same time having all conductors accessible.
5. Advantages to be gained by the use of iron pipes as an interior conduit, not only as a matter of safety, but economy.
6. The advantages of an inspection of electrical work, not merely by making electrical measurement after the work is completed, but by having practical men see that the work is mechanically perfect as the work is being done.
7. The great advantage of having complete detailed working plans of wiring construction, in order to be sure that the work is properly laid out, and is installed as it is laid out; and in order that the work may be at any time easily maintained and readily changed or repaired by any intelligent workman.

Electricity for Canal Boats.—It is stated that experiments on a tolerably large scale are now being made on the Erie Canal with a view to seeing how far the electric trolley may be applied to the propulsion of vessels. The Westinghouse people are erecting a line over the section from Rochester to Westport, New York, whilst the General Electric Company are responsible for a length of three miles west of Albany, New York, on which the experiments are carried on. A maximum speed of five miles per hour is aimed at.

A NEW INCANDESCENT ARC LIGHT.*

BY L. B. MARKS, M.E.

Electrical literature is replete with studies of the incandescent lamp as a source of artificial illumination; the performances of arc lights under a great variety of conditions have also been published from time to time; but the subject of the so-called incandescent arc, singularly, has received little or no attention.

In view of this fact, it has seemed desirable to report at once on a series of investigations which, though still incomplete, have disclosed some remarkably interesting and important phenomena with reference to a new form of incandescent arc light. The experiments have been carried on far enough to demonstrate that this source of illumination is *sui generis* While possessing the main characteristics of the ordinary arc, it is also akin to the incandescent light, and may be said to constitute a mean between these two.

The Typical Incandescent Arc.—The incandescent arc has been described as one in which the "two electrodes are in imperfect contact," the current thereby meeting with a high resistance and producing heat effects, which manifest themselves in the incandescence of one electrode and the formation of a number of very small arcs between the uneven parts of the electrodes in contact.

On this principle, Reynier, Werdermann, Joel, Tommasi, and others constructed lamps years ago, but for well-known reasons none of these "semi-incandescent" lamps, as they were called, found much practical application. The Sun lamp of Clerc and Bureau was a modification of the others, the arc impinging on the surface of a block of marble or condensed magnesia between the tips of the electrodes. In this form there was a rapid waste of the non-conducting substance interposed, and a diminution in the efficiency of the light.

The New Incandescent Arc.—The incandescent arc to be treated of in this paper differs radically from any of the forms alluded to above. In it, the electrodes are not in contact, while the current is indirectly used in maintaining all the products of disintegration of the carbon in a state of incandescence or opalescence.

The arc is enclosed in a small envelope, which is made of highly refractory glass. The envelope is closed at the bottom and provided on top with a metal plug having an opening in it just large enough to admit of the feed of the upper electrode. A fireproof plug of asbestos pulp insulates the metal from the glass. A valve in the plate allows the egress of gas, but prevents ingress of the air. With this construction the operation of the lamp will be as follows: Upon the closure of the circuit, and the springing of the arc, the air in the enclosing envelope is robbed of its oxygen, the latter uniting with the carbon of the electrodes to form CO and CO_2 gases. The gases are brought to an exceedingly high temperature, at which they maintain the carbon vapour issuing from the arc. This vapour is deposited in the form of a thin coating on the internal surface of the glass chamber. The expansive force of the gases may become sufficiently great, if no means of egress be provided, to rupture the envelope; hence, a small safety valve is provided for their outflow. The only possibility of ingress of air is through the narrow space between the positive carbon and the plug; experience has shown that after the temperature has been raised beyond a certain point the amount of air that enters in this way is inappreciable: in any event, the oxygen is immediately converted by combination.

It is important that the enclosing glass envelope be as small as possible, for the conservation of the radiant energy, and hence the efficiency, will depend largely upon the size of the chamber. The heat which in the ordinary arc light is dissipated in the air is here conserved, and raises the temperature of the enclosed gases and vapour of carbon. The proper conditions being fulfilled, the lamp maintains its maximum efficiency shortly after the current has been passed through it, and glows like the incandescent with the brilliancy of the arc light. The arc proper is scarcely visible, but the entire contents of the chamber seem to be luminous, giving the appearance of a solid cylinder of light.

* Abstract of a paper read at the International Electrical Congress, Chicago

The pressure, as well as the temperature of the enclosed gases, has a very important bearing on the performance of the lamp, and affects to a marked degree the character of the carbon deposit on the glass chamber. At this date no definite figures can be given, but it appears that a high tension is absolutely required to give good results. The structure and constituency of the electrode are also pre-eminently important. Absolute purity of the carbons is imperative. Investigators in this field have apparently found it impossible to obtain all the requisite conditions. Beardslee mentions a type of lamp similar to the one under discussion, but whether the size or character of the arc-enclosing chamber, the nature or management of the gases, or the quality of the electrodes, or other features made his arrangement impracticable, is not recorded. Suffice it to say, the comparatively poor grade of arc light carbon manufactured 10 years ago would alone explain his failure.

It is interesting to note here that attempts have been made at various times to save carbons in arcs by excluding the oxygen of the air. Baxter devised several forms of arc lamp with this object in view. The subject has been more recently referred to by Thompson. These experiments were attended with little practical success, not because the desired ends were infeasible, but probably because, as in the case of Beardslee's apparatus, alluded to above, one or more of the requisite conditions had not been attained. It appears that the saving in life was more than counterbalanced by the loss in light. The "incandescent effect" was absent, and the unsteadiness of the arc itself was fatal. The results were almost identical with those obtained when the arc is formed *in vacuo*. In this case there is a tendency of the carbon to deposit as a soot on the sides of the vacuum chamber, an effect consequent upon the vapourised carbon in the arc being carried off and condensed again as soon as the vapour escapes the heat of the arc stream.

But the requisite conditions hereinbefore named being once attained, the arc is really a beautiful phenomenon. It differs in many respects from the arc in open air, being especially steadier than the latter. The light emanating from the incandescent vapour of carbon appears to issue from all parts of the small enclosing envelope, the area of the source of illumination being limited only by the size of the chamber.

Efficiency Measurements.—Measurements of the efficiency and candle-power of the light were made in the laboratory of Cornell University. The method employed in making the efficiency tests was that used by Nakano in determining the efficiency of the arc lamp, and subsequently by the writer in an investigation on arc light carbons. The ratio of luminous to total radiation of the lamp was taken at different angles below and above the horizontal. The value of the mean hemispherical efficiency is found to be 8·4 per cent. The mean efficiency of the ordinary arc is about 10 per cent. The mean efficiency of the incandescent lamp, according to Merritt, is rather below than above 5 per cent. The value obtained in the test of this new light therefore lies between those of the two present forms of electrical illumination, approaching, however, more nearly that of the arc. While it is true that the average efficiency of the electric arc in open air nets about 10 per cent., it is questionable whether in commercial practice in this country this value is often reached. The writer has made tests of a standard brand of arc light carbon where the efficiency was only 7½ per cent.

Tests were made to determine the effect of initially coating the internal surface of the cylinder with various ingredients other than carbon. No marked difference in the efficiency was discovered. The distribution of light differs considerably from that of the ordinary arc. Especially is this true at angles greater than 50deg. below the horizontal. To the naked eye the intensity of luminous radiation does not seem to vary much from 20deg. to 60deg. below the horizontal, while in the arc the change is very marked between these limits. The results of tests show that the mean hemispherical candle-power of the ordinary arc averages about 600; the mean watts candle ·84, or 888 candles per electrical horse-pow

(To be continued.)

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TO CORRESPONDENTS.

THE B. A. MEETING.

From Edinburgh to Nottingham, though twelve months intervene, is the cry of the British Association, whose annual meeting commences next Wednesday at the latter town. It was in 1866, under the presidency of Sir William, then Mr. W. R. Grove, a man whose name will live long in scientific history as one of the first to attempt the centralisation rather than the diversifying of scientific thought, when the meeting previously met at Nottingham. A very interesting study might be founded upon the cyclic tendencies of scientific discussion. The rampant subject around the year 1866 was—dredging. Since then we have had other subjects much more prominent, among which electrical matters shine conspicuous. Deep-sea sounding and dredging are, however, by no means unimportant subjects to the electrician, especially to those of the craft who are engaged in cable work. They must know something of the depth of water and the character of the bottom, and the more they know the better for their work. Perhaps, if the truth was known, such expeditions as those of the Silvertown Company to the African and American coasts have done more to delineate the surface of the ocean bed around these coasts than all the governments combined. In this connection, then, the work of the British Association in fostering expeditions of the "Challenger" kind, cannot fail to deserve recognition. From 1866, coming to 1893, we are fain to ask if there seems to be foreshadowed any important subject which will be discussed in the interests of electricity, and, in answer, to say there seems to be none. That there will be some papers discussing questions relating to the borderland of science is known, but for all practical purposes anything said of this dreamland is only of passing interest to the world of to-day. The real knowledge obtained is small, even if there be any reality, the attempt to investigate being more from the desire to form theories to fit facts rather than to classify facts and obtain laws. Was it not Max Muller, in his admirable lecture on the "Science of Language," who describes all science as passing through three stages—the empirical, the classificatory, and the theoretical. Sometimes it appears to us as if electrical science was a jumble of the three, its votaries being either empirical, classificatory or theoretical just as it suits their purpose, and with drum ecclesiastic would cram their views down the throats of hearers. It is in this particular that we cannot countenance the ordinary electrical preacher of the day. He arrogantly claims absolute infallibility, and will not admit of doubt, though appeal to time will show that really his views are as changeable as the weathercock. Hence we venture to question the wisdom of too easily falling a prey and accepting the conclusions of those who make excursions into the borderland of science. Their work is honest, it is interesting; but a few more such excursions, a little extension of our knowledge, will probably show that the conclusions put forward require modification. The secrets of Nature must be very simple indeed if the *savants* of the nineteenth century are

to solve them. We must leave a little for future generations. It is well to know that from the forecast of the address of the sectional president of Section A, he is not so sanguine of finality as some of the less able but more ardent physicists seem to be. He is to discuss the properties of the ether to fulfil the requirements of our present views relating to light and electricity, and try to show by such discussion whether science is able to predict what electricity is. The answer, according to an inspired source, is likely to be, "Man knoweth not." But of this, more anon. Unfortunately, with one exception—Section G—the sections are not worked on business principles. This is the fault more of the contributors of papers than of the secretaries. The men who contribute to Section A are too big to bully, so that frequently the papers are not completed before the meeting, sometimes not even when read, and to properly report such proceedings is a task beyond the powers of a literary Hercules. The members supporting Section G are of a different class—they understand business matters, and with solitary exceptions make our task as easy and as pleasant as is possible. Although, then, the outlook does not seem favourable to much new electrical matter, we hope in the usual course of things to give the presidential addresses that at all bear upon matters with which this paper is concerned, as well as the papers that may be discussed. To those of our readers who do not know Nottingham we would say that the local committee has made excellent arrangements for the pleasure side of the show, and that, though Nottingham itself may be deficient in interest, the surrounding district will well repay examination.

FESTINA LENTE.

Nowadays there is a wide-spread feeling, sometimes emphatically expressed, that the name of "Stick-in-the-Mud" is a suitable appellation to confer upon anyone who does not wear seven-leagued boots in travelling along the highway of life; but one may surely be pardoned for a wish to maintain a steady pace, if slow, seeing that, after all, there is no particular object realised, to the world, by getting to our journey's end any sooner. Apparently, it is not even as though humanity or the conditions of existence were very greatly benefited by quickening the pace of life; at least, our social system must be completely wrong if the progress of generations can give us really nothing better than a more rapid rate of living. To desert theory and discuss prosaic facts, what is the special advantage of travelling at an average speed three or four times as great as that which was customary a hundred years ago? Of course, to ask such a question is to exhibit a somewhat marked reactionary spirit; but is it altogether unreasonable? Let us assume that the "zeitgeist" continually calls for developments, and makes us do more in a given time than our grandfathers: is this spirit an evil one due to artificial conditions, and, therefore, probably as bad as they make them; or does it arise from the action of natural laws which we may not like, but which somehow or other insist in the end upon obedience?

This nice little problem is to our mind worthy of development and solution, even so far as the present conditions of life pertain: how much more, then, will it be affected by a consideration of what is likely to come in the future, if things go on as they have done. To-day we travel on the main-line railway expresses, driven by reciprocating steam locomotives, at an average speed all told of from forty-five to fifty miles per hour, and can get through more space (and presumably more work; but let us not be too sure of that) than our grandfathers, in the proportion of four to one. Our grandsons, however, will not—according to some people—be contented with this, but must live at a still higher pressure: therefore let preparations be made for them by scheming out plans and designs for transit across the country at speeds more than double those now given by express services.

Of course, if a man desires to live in the memory of his descendants as a go-ahead individual, who dreamed away his life in the details of what was to come, he could not do better than use the seven-leagued boots of which we have spoken, and so keep a long way in front of everybody else on an open road, not, like the true inventor, finding out a new course over a district hitherto trackless.

In another column are given some details of a scheme just introduced to public notice, and dealing with the idea of rapid transit at a speed of one hundred and fifty miles per hour. Putting the matter in a plain outspoken way, what, we would ask, is the earthly good of developing such a scheme in this fashion, and under present conditions? What financiers would to-day, or to-morrow either, care to associate themselves with the proposal, or to subscribe a penny towards it, on a scale at all commensurate with the suggestion? Is there any public demand for speeds so great as this; and, above all, could a line of the type proposed be built for a reasonable sum (including parliamentary charges, cost of land, etc.), and then be certain of traffic enough to pay even moderate dividends?

If the object of this proposal is to develop electric traction, the promoters might with advantage begin more modestly, and help to foster and create electric tramways, first of all, to run at a speed of ten, or even twenty miles an hour. Short electric railways acting as feeders of the main lines would then follow as experience grew and the electric railroaders became more confident; but to our mind it is absolute waste of time and energy to work out, even on paper, the details of a main-line service calculated at once to make a huge step forward, and involving the exercise of such knowledge and skill as, in point of fact, can only come through years of preliminary work on a smaller but gradually increasing scale.

No one would deny that a speed of one hundred and fifty miles an hour can be achieved on an electric road; there is no particular reason, indeed, why the promoters should have contented themselves with this figure. While ... at it they might

just as well have gone a little higher and made it two hundred and fifty. The difference is only one of degree—and years.

The time is not ripe for such proposals, and they might therefore be dismissed with a wave of the hand were it not that the man in the street is attracted by such an exercise of the creative faculty, and therefore deems a less important and imposing plan to be naught. The man in the street is wanted to give his support and subscribe his pence and pounds to the tangible and immediate systems that are crying out for development—the street tramways first of all—that is, if satisfactory proof can be shown that to work them electrically is to work them profitably. Then the short railways may follow, and possibly, in the far future, our main lines will be converted by the genius of Faraday to be used at speeds only limitable by the purchasing power of a sovereign. Unlike Gilpin's chronicler, we are, however, thankful that we shall *not* be there to see.

CHICAGO.—August 25th.

The following is the resolution on units adopted by the Electrical Congress:

Resolved, That the general governments represented by the delegates in this International Congress of Electricians be and they are hereby recommended to formally adopt as legal units of electrical measure, the following:

As the unit of resistance, the international ohm, which is based upon the ohm equal to 10^9 units of resistance of the initial C.G.S. system of electromagnetic units, and is represented by the resistance offered to an unvarying electric current of a column of mercury at the temperature of melting ice, 14·4521 grammes in mass, of a constant cross-sectional area, and of a length of 106·3 centimetres.

As a unit of current, the international ampere, which is $\frac{1}{10}$ of the unit of a current of the C.G.S. system of electro magnetic units, and which is represented sufficiently well for practical use by the unvarying current, which, when passed through a solution of nitrate of silver in water, in accordance with accompanying specifications, deposits silver at the rate of 0·001118 of a gramme per second.

As a unit of E.M.F., the international volt, which is the E.M.F. that steadily applied to a conductor whose resistance is one international ohm will produce a current of one international ampere, and which is represented sufficiently well for practical use by 1,000/1,434 of the E.M.F. between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of 15deg. C., and prepared in the manner described in the accompanying specifications.

As the unit of quantity, the international coulomb, which is the quantity of electricity transferred by a current of one international ampere in one second.

As a unit of capacity, the international farad, which is the capacity of a conductor charged to a potential of one international volt by one international coulomb of electricity.

As the unit of work, the joule, which is 10^7 units of work in the C.G.S. system, and which is represented sufficiently well for practical use by the energy expended in one second by an international ampere in an international ohm.

As the unit of power, the international watt, which is equal to 10^7 units of power in the C.G.S. system, and which is represented sufficiently well for practical uses by the work done at the rate of one joule per second.

As the unit of induction, the henry, which is induction in a *circuit* when the E.M.F. induced in this circuit is one international volt while the inducing current varies at the rate of one ampere per second.

There was also presented a report of the committee appointed to consider the question of standards of light. The committee says it has had much discussion upon the various forms suggested for standards, and in particular upon the two special forms of lamp known respectively as the amyl-acetate lamp of Von Hefner Alteneck and the pentane lamp of Vernon-Harcourt. It was unable to arrive at a vote recommending either, however, and therefore recommended that all nations be invited to make researches in common on well defined practical standards and on the convenient realisation of the absolute unit.

THE PRACTICAL MEASUREMENT OF ALTERNATING ELECTRIC CURRENTS.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

LECTURE IV.

MEASUREMENT OF ALTERNATING-CURRENT ENERGY.

In this fourth and last lecture I propose to discuss the practical measurement of alternating current energy and alternating-current quantity. In so doing we shall begin by dealing with the easier problem in the measurement of such quantities—viz., when the circuits to which the power or current is being supplied are non-inductive—and then proceed to consider the more difficult case in which the circuits are inductive circuits, such as the primary circuits proceeding out from alternating current stations.

Instruments for the measurement of alternating current energy or quantity are called simply meters, and they are classified into ampere hour meters and watt hour meters. A complete classification of all the different forms of meter already invented would be a rather difficult thing to make on a perfectly correct basis. I shall give you presently an approximate classification. In the first case we will consider the simplest forms of meter, which may be called graphic ammeters and wattmeters.

Of these two, the Holden ammeter and Mengarini wattmeter are good examples. In these instruments an arm carrying a pen is displaced over a paper-covered drum, which is revolved uniformly in 24 hours by a clock. The motion by which the pen is displaced is regulated by a part of the instrument which is simply an ammeter or a wattmeter, and the displacement of the pen is proportional to the current or the power passing through this measuring part. When, therefore, the diagram is cut off and unrolled, we find on the paper a curve which represents, by its ordinates, either the power or the current at any instant; and, if the whole area of the curve is integrated, then such area represents the whole energy or quantity which has passed through the meter in 24 hours. These instruments have the advantage, therefore, that we practically record two quantities at once; and they serve two purposes of indicating the instantaneous current or power and the total current quantity or energy, but they have the disadvantage that they are not self integrating.

Next in order of simplicity are the self integrating ammeter and self integrating wattmeters. One of the simplest of those self-integrating ammeters, but which is, however, available only for the measurement of alternating-current quantity, is the well-known Shallenberger meter.

Before me on the table are a series of meters, lent by different firms, and these I will put in motion, in order that you may see the movement.

The principle of the Shallenberger meter is not a difficult one to understand. It consists (see Fig. 1) of a small transformer, one coil of which we may call the primary, and which is in series with the circuit in which the current to be measured is flowing. The core of this transformer consists of a little soft iron disc, which is capable of revolving on an axis. This axis is geared at the top with a counting mechanism, which records the number of revolutions of the disc, and at the bottom there is a vane or fan of thin aluminium, which serves to retard the rotation of the disc.

The secondary circuit of this transformer consists of a small coil of copper, which is closed upon itself, and which is placed with its axis inclined at 45deg. to the axis of the primary coil. When the primary current flows through the primary coil it does two things—it magnetises the core, and it induces a secondary current in the closed secondary circuit. It is not difficult to show that the phase of this secondary current must be about 90deg. behind the phase of the primary current, and also that the magnetism of the iron core, which is in a direction at right angles of the plane of the primary coils, also lags in phase behind the primary current by about 90deg. The magnetism of the core and the induced secondary current are, therefore in step, and are in such directions that the axis of the disc is always being pulled round by the induced field of the secondary coil. If, then there were no friction of any kind, the iron disc would be continually accelerated in speed, but since the air friction varies approxi-

* Cantor lectures, delivered before the Society of Arts.

mately as the square of the velocity, and since the mean driving force is proportional to the mean square of the current strength, it follows that the total number of revolutions which the disc makes in any given time is proportional to the total mean quantity or ampere hours which have passed the primary circuit. The meters can therefore be calibrated by a constant in such a way that they read directly ampere hours, and if the pressure between the mains is kept constant, they may be graduated to read in Board of Trade units.

These meters are very simple to construct and very fairly accurate in performance, and they have, therefore, come into extensive use. The velocity of the disc being at any time proportional to the mean current passing through the meter, we can, if the current is kept tolerably constant, employ the instrument as an ammeter. By moving the position of the secondary coil, a little adjustment can be made in the meter for change of frequency, and the meter can be calibrated for the particular frequency for which it is intended to be used.

Taking the particular meter before me, which is a 10-ampere meter, it starts with less than half an ampere and reads up to 10 amperes. The greatest variation within this limit in accuracy of reading is about 3 per cent. The meter has, therefore a range of about 1 to 25, and with care in adjustment can be made to read more accurately than the above mentioned figure.

The next meter in order of simplicity, and very similar in principle to the Shallenberger, is the Wright-Ferranti meter. It is also a self integrating ammeter; it measures at any instant the mean square current, and gives us the mean quantity which is passed through the meter. Looking at the diagram, Fig. 2, we see that the indicating part of the meter consists of a wheel with a light iron rim. This wheel is nearly embraced by two curved horns of laminated iron. These horns spring from the corners of a rectangle of laminated iron. This laminated iron rectangle is wound over on all four sides with two coils of wire. Through one of these coils the current to be measured passes, and the other coil is a shunt coil, the function of which I shall describe presently. The arrangements of the coil are such that any moment the ends of the curved horns are opposite magnetic poles. On these curved horns are placed copper rings. When the alternating current passes through the series coil it creates alternating magnetism in these curved horns, but owing to the eddy currents of the set up in these embracing rings, the magnetic lines of force are thrust outwards, making a lateral leakage field, which travels up the horn. This leakage field induces eddy currents in the iron disc, and the disc is thereby repealed in virtue of the electromagnetic repulsion set up between the horn and the wheel. An experiment to illustrate this repulsion can easily be shown.

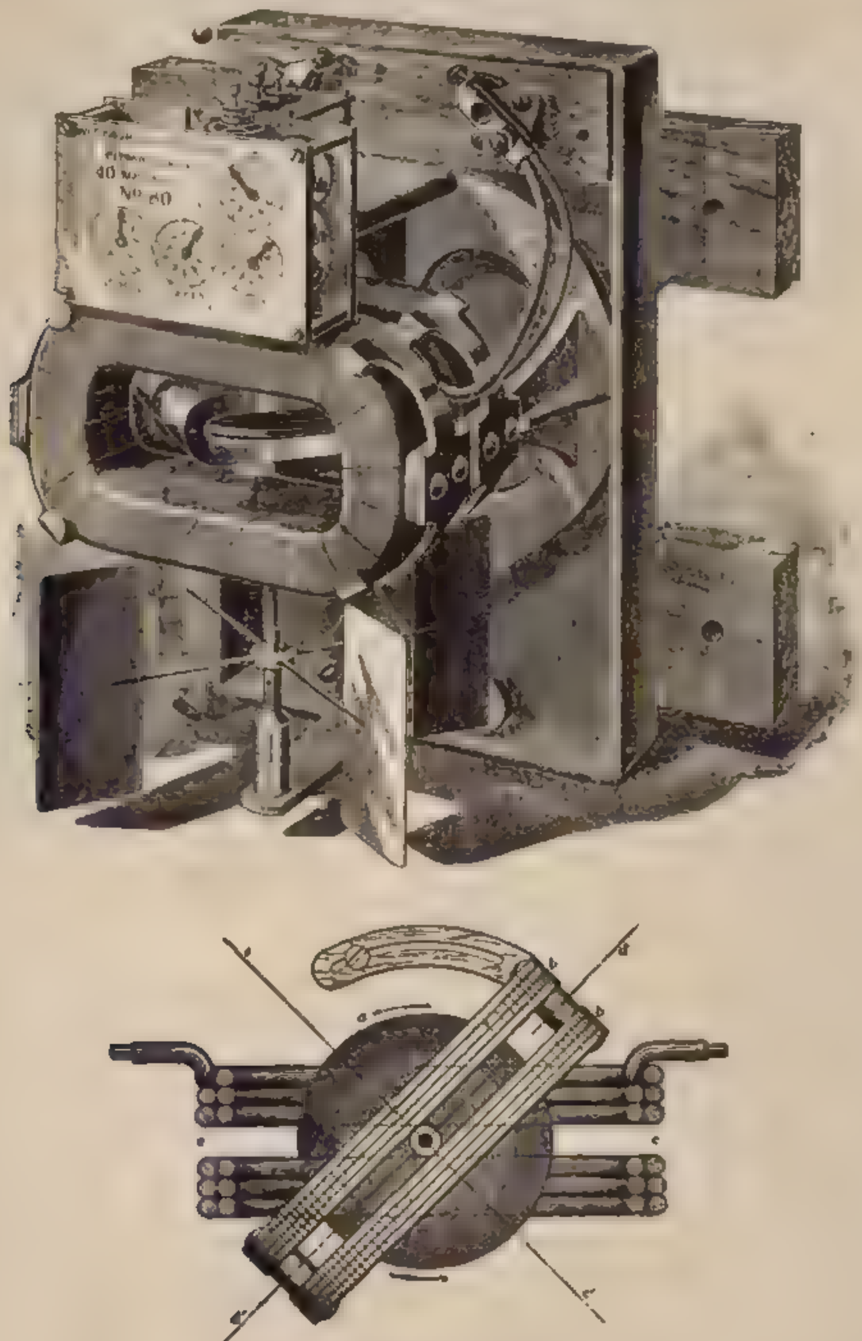


FIG. 1.—Shallenberger Meter.

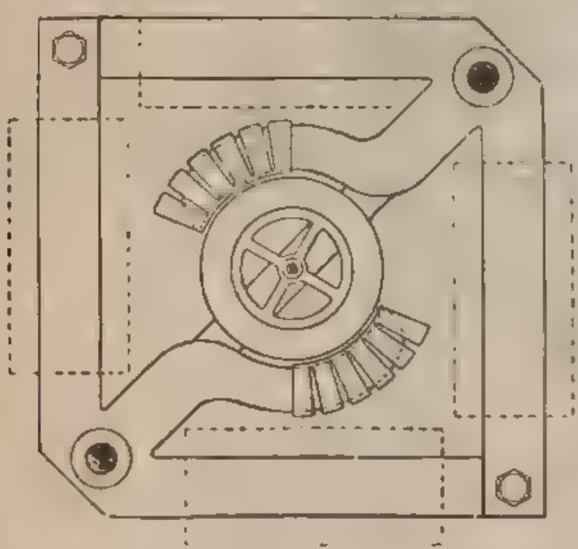
In front of me is a large alternating-current magnet. Across the top of this magnet I place a laminated iron bar. The laminated iron bar is embraced at intervals with copper rings. If I set the alternating current magnet in action, and if I hold the soft iron disc mounted on a pivot near to the laminated bar, it begins to revolve rapidly. We may explain this in another way, by saying that there are a series of alternating magnetic poles running up the iron bar, and that these alternating current poles produce other induced poles in the iron, and so drag the disc round. All these effects of electromagnetic repulsion were more fully explained by me in a lecture once given in this place.

Returning, then, to the Wright-Ferranti meter, you will note that the axis which carries the wheel has upon it four aluminium

or mica vanes, and is also connected at the top to a counting mechanism. When an alternating current is passed through the meter it tends to drive the wheel round with a speed which is proportional to the mean square strength of the current, and, therefore, it follows that the number of revolutions made by the wheel at a given time is proportional to the mean quantity in ammeter hours which has passed through the meter at that time.

The meter before me is a 20 ampere meter, which starts with a current of about half an ampere, and reads up to 20 amperes. Within these limits the greatest deviation in accuracy is only about 1·8 per cent. Both the Shallenberger meter and the Wright-Ferranti meter require to be calibrated for the particular frequency for which they are to be used, and they only give Board of Trade units provided that the pressure is kept constant between the supply mains. The meter really reads quantity directly, and power only on the assumption of the constancy of pressure.

I mentioned a moment ago that there were two circuits on the electromagnet, and that one of these was the shunt circuit. The



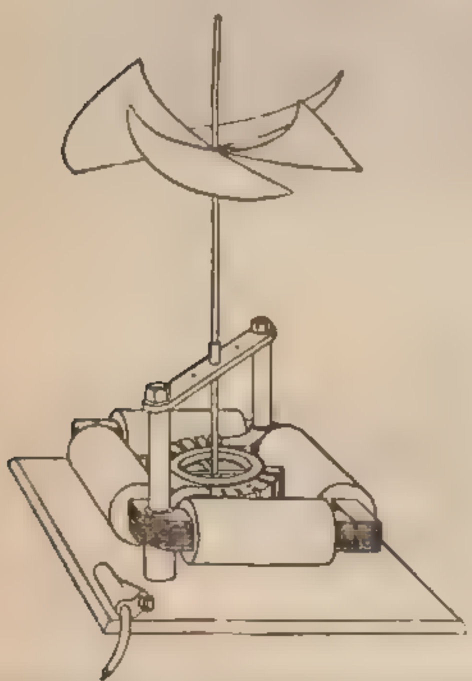


Fig. 2.—Plan and General View of Wright Ferranti Self-Starting Alternating Motor Working a Fan.

function of this circuit is to supply the driving force which overcomes the friction of the counting train. If this shunt circuit were not present, there would be a frictional resistance to be overcome before the meter would start at all.

Another meter, of a tolerably simple character, also intended for measuring ampere hours, is the windmill meter, invented by Prof. Forbes some years ago. In that meter, Fig. 3, there is a coil of wire, which was heated by the current passing through it. This heated coil generates an upward current of air, and this upward current of air is made to turn round a very delicately constructed windmill with mica vanes. The counting train attached to the windmill records the number of turns in a given time. Although this may seem to have been a somewhat unpromising principle to apply, yet the meter in itself gave excellent results.

We turn next to the consideration of the second great class of meters—namely, the watt hour meters which are self integrating. These self integrating watt hour meters may also be divided into *two classes—continuously* and intermittently integrating.

Taking the last class first, this is well represented by the Frager meter. In this meter there are two distinct parts: first, the watt meter part, which measures at any instant the power; and the integrating part, which integrates at intervals the power and the time. The wattmeter part, as you will see, on looking at the instrument, consists of a wattmeter having a thick coil, which is a series coil, and a movable coil, which is suspended by a steel wire which is a shunt across the circuit. The terminals of the shunt coil are connected to the two sides of the mains, and the current to be measured is passed through the series coil. Attached to the movable shunt coil is a long arm, and the displacement of this arm varies with the power passing through the instrument. Adjacent to the wattmeter, and fixed on the same base, is an electrical clock, which drives round a curved plate of metal, which is technically termed "the snail." On the end of the long projecting arm attached to the wattmeter is a small steel point. As the snail is turned round it passes underneath this arm, and if this arm is displaced, the length of the path of the pointer, when travelling over the snail, is proportional to the power passing through the wattmeter. The snail plate is so suspended that when the pointer passes over it, it presses it down, and makes an engagement between the snail and the counting mechanism.

At each revolution of the snail the counting mechanism is turned round by a number of revolutions which are proportional to the mean power or watts passing, and hence the total number of revolutions in any given time is proportional to the watt-hours which have passed through the meter. The snail revolves round in a period which is about three minutes, and hence the record is, as it were, made of the power passing through the wattmeter only at intervals of three minutes. If the current which is to be measured does not vary very rapidly, such an intermittent recording meter may be made to give very accurate results, but there are many cases, such as in theatres, where the amount of current passing through the meter is very irregular and rapidly varied. Under these conditions the wattmeter needle is thrown about in such a manner that the actual power recorded on the dials at every revolution is not always the true mean power passing in the interval between two revolutions and the readings of the meter may therefore

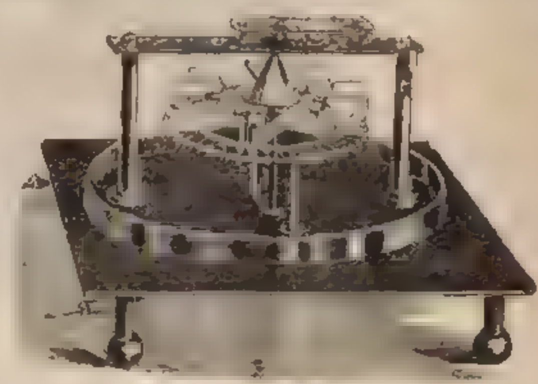


Fig. 3.—Forbes Meter.

become very erroneous. Practice has confirmed these inferences, and although the Frager meter is under some conditions of use a very accurate meter, there are other conditions under which its readings are not to be depended on.

Coming next to the continuously recording watt-hour meters, we reach that class of meter which may be said to be the best adapted for general wants, and one of the most efficient of these continuously recording watt hour meters is the one invented by Prof. Elihu Thomson. The Thomson recording wattmeter is, as you will see from the specimens before us, a wattmeter in which one coil, called a series coil, carries the current to be measured. These series coils really form the field magnet of a very small electromotor. The armature of this motor is a beautiful one having a small commutator and brushes of the usual kind, and this armature circuit, together with the external added resistance, constitutes the shunt circuit of the wattmeter. When the meter is attached to a circuit, the main current of which passes through the series coils, and the shunt coil being attached to the two mains, the armature begins to revolve. The shaft which carries the armature carries also a copper disc, which is embraced by three horseshoe magnets. When the disc revolves, eddy currents are set up in the disc which retard its motion. The number of revolutions of the disc in a given time is recorded by the counting mechanism attached to the shaft. Then since the force driving the armature round is at any instant proportional to the power passing through the instrument, and since the retarding force is proportional to the velocity, it follows that the number of revolutions in a given time represents the watt hours that have passed through the meter. In order to overcome the constant friction of the train, there is a compound winding on the field magnet, consisting of a few turns of the shunt coil, which is arranged in such a direction that the driving force due to the fixed and movable shunt winding tends to overcome the permanent friction of the armature shaft. By properly treating the permanent magnets, it is found that they retain a constant magnetism for long periods of time. The meter is so arranged that when working on a 100-volt circuit, the shunt coil has a resistance of 1,000 ohms altogether, and takes, therefore, ·1 of an ampere.

The loss in the meter, therefore, is only 10 watts, which is the power taken up in driving the meter. By properly arranging the shunt coil, it is possible to make the constant of this meter perfectly constant for a very large range of its action, and one great advantage which this meter has is that it can be employed with both alternating and continuous currents. When properly adjusted, this watt hour meter is capable of very great accuracy in the measurement of alternating current energy.

There are several other meters, which time will hardly permit me to describe fully, but a brief allusion may be made to them.

One meter before me is called the Brillie meter, and is of the type of the Frager meter, that is to say, it is an intermittent recording wattmeter. Another meter, of which I spoke at the beginning of the lecture—namely, the Mengarini recording wattmeter—is also before me. This last meter has been extensively employed on the alternating-current circuits of the Rome electric lighting station.

Reviewing, then, the whole of these meters, we may say that a rough classification of meters for the measurement of alternating currents may be made as follows:

1. Graphic recording ammeters.
2. Graphic recording wattmeters.
3. Continuously recording ampere hour meters.
4. Intermittent recording wattmeters.
5. Continuously recording wattmeters.

We may ask ourselves at this stage what ought to be the characteristics and requirements in a good commercial meter for the measurement of electric energy supply to houses for lighting and other purposes. Most persons without experience would probably say that the first requirement in a meter is accuracy; but as a practical matter accuracy is not of so much importance as that the meter should never go far wrong. A type of meter which is capable of measuring, under some conditions, to ·1 of accuracy, and at other times is liable to make errors of 150 per cent. in actual practice, is not nearly so useful as a meter which will not read closer than 1 per cent., and yet which, in actual practice, never proves to go more than 3 per cent. wrong.

The next condition which a meter must comply with is that of the consumption of small power. Since the meter is connected to the circuit continually, if it absorbs power, the sum total of all these consumptions may amount to a serious item. We have pointed out, in speaking of voltmeters, that a continuous power absorption, say of 20 watts, during the whole year, amounts to a yearly consumption of 160 units of electric energy, and that, therefore, small power consumption is certainly an important item in appraising a meter.

The third great requisite is, that the meter ought not to require elaborate care and delicacy in fixing, and that it ought to be hardy enough to be easy of carriage. House meters have to be fixed in places which are sometimes subject to vibration and dampness, etc., and a meter for house purposes ought, therefore, to be hardy enough to stand those conditions.

The fourth condition is, that the meter must be so constructed in principle as not to be capable of being easily tampered with, or its indications made to vary, even when enclosed in a lock-up case.

To the above requirements ought, of course, to be added the broad and general conditions of simplicity of structure and cheapness in price, as far as consistent with good workmanship.

I now turn to the important subject of the measurement of alternating current power when supplied to inductive circuits; in other words, we have to study alternating current primary meters. In the distribution of alternating currents for commercial purposes, not only is it necessary to be able to measure the power or energy supplied to the consumer on the lamp circuits, but it is also necessary to be able to measure the power and energy sent out from the alternating current station which is supplying generally, transformer circuits. Hence we have to consider the special difficulties of making such measurements on circuits which have a considerable self induction, or in which the power factor of the circuits is below unity.

During the past year or two I have paid particular attention to this subject in a long series of researches on the efficiency of transformers, and have thereby been led to study most of the various methods which have from time to time been proposed for measuring alternating-current energy.

I do not propose to occupy the time—already brief—in discussing any of the methods which, however well they look on paper, are yet, for some reason or other, inapplicable in practice, but to describe the methods which have proved themselves in my experience satisfactory and practicable in making these measurements. I have found that the two instruments for this purpose which are capable of being employed with very satisfactory results for the measurement of alternating current energy on inductive circuits are the Thomson recording wattmeter and the Mengarini wattmeter already described.

Generally speaking, these measurements have to be made on high tension circuits. Take, for instance, the very common case of an alternating current station, supplying alternating current at a pressure of 2,000 volts on transformer circuits. One method of employing either of the above wattmeters as energy meters would be to place a non inductive resistance of sufficient magnitude in series with a shunt coil, and to put the series coil in the series with one of the primary mains.

In such an arrangement there would be certain disadvantages. In the first place, the Thomson recording wattmeter takes a current of about one tenth of an ampere through the shunt, and hence we should have to add to the shunt coil, the resistance of which is about 1,000 ohms, another 19,000 ohms of non-inductive resistance, and then when this was done the power wasted in the whole of these shunt circuits would be 200 watts. If these shunt circuits were kept connected to the mains throughout the whole year, the waste of energy in these shunt circuits would be something like 1,600 Board of Trade units, and if we reckon the manufacturing cost of these at only 2d. a unit it would cost something like £12 per annum merely to supply the shunt circuit with current. But this difficulty can be got over and also the difficulty of constructing a large non inductive resistance of 20,000 ohms, sufficiently well divided up not to be in any danger of breaking down with 2,000 volts pressure by the adoption of a transformer to excite the shunt circuits in the way described in my last lecture. A small transformer is employed, transforming down from 2,000 volts to 100 volts, and as this transformer is only to supply one tenth of an ampere on its secondary circuit, it can be made very small, not more than, say, a tenth of horse power in capacity. It can, therefore, be made to waste not more than about 10 to 20 watts in itself. This transformer has its primary circuits connected across the primary mains, and its secondary circuit is connected across the terminals of the shunt circuit of the Thomson wattmeter, and so joined up that the current in the shunt circuit of the wattmeter is in the same direction and has the same magnitude as if the wattmeter were joined up simply on a 100 volt circuit in the ordinary way.

The wattmeter in itself only wastes about 10 watts in its shunt circuit, and, therefore, the whole arrangement of the transformer and wattmeter can be made to waste not more than, say, 25 to 30 watts, instead of 200, and reduce the cost of up keep to something like 200 units a year instead of 1,600. The primary current going out of the station is then taken through the series coil of the Thomson wattmeter, and in order to keep all the parts of the wattmeter at the same potential, one terminal of the secondary circuit, and the little transformer, is also joined up to the primary main on the side nearest to it.

It is usual to mount the transformer and wattmeter on one board, and then to insulate the whole of this board well. The first step is to calibrate the wattmeter. This can be done most easily on a 100 volt circuit by passing through the meter known powers, and observing the reading of the dials. The constant of the meter then has to be multiplied by the transformation ratio of the small transformer in order to obtain what may be called the high tension constant of the meter. When this is done, the meter can be set up in the station in such a way that the whole current going out of the station passes through the meter and the engineer can, by taking observations from day to day, record the whole number of units which have been sent out from the generating station on the primary circuits in any interval of time. In exactly the same manner I have found it possible to employ a Mengarini wattmeter coupled with a transformer and placed on the primary circuit. This has the advantage that it not only enables us to record the whole of the energy going out of the station in a given time, but to know at any instant the primary watts.

Before placing confidence in either of these two methods, I made a very careful series of observations on an inductive alternating-current primary circuit, in which I employed the Thomson self-integrating wattmeter as above described, to measure the whole number of units sent out along that primary circuit in four hours, and at the same time observations were made on the same circuit by means of a wattmeter to obtain the power sent out at intervals of minutes. When these observations were compared and reduced, it was found that the power sent out in four hours, as determined by the observations, was 66·924 units in the wattmeter, and the energy given by the self-integrating Thomson wattmeter in the same time was 66·946. It thus became evident that the Thomson recording wattmeter was capable of giving very accurate results as a primary wattmeter, and that there is no reason whatever why the record of the primary energy sent out should not be made in alternating current stations with the same accuracy as in the case of continuous current stations.

To complete arrangements it would be desirable, in the case of an alternating-current station, in order to enable the engineer to know exactly what the result of his working is, to act as follows:

On the primary should be placed in the first place, an ammeter, capable of measuring alternating currents and giving the mean square value. In the second place, an electrostatic high tension voltmeter should be connected across the mains in order to give the high-tension volts. In front of this instrument should be placed a Mengarini wattmeter and a Thomson self recording wattmeter, the whole primary current from the station going through the series coils of these instruments. The shunt circuits of these instruments should be excited by a small transformer, transforming down from a working pressure of 100 to 50 volts. These instruments would then enable the engineer, by daily readings, to record, first, the energy sent out of the primary circuits in Board of Trade units in any time; secondly, the power being sent out at any instant measured in watts; thirdly, the primary current being sent out at any instant, and the primary pressure, and, therefore, from the product of these two, the apparent power being sent out at any instant; and, fourthly, from the readings of the real and apparent power, the power factor of the station could be ascertained at any instant.

By comparing these readings with the sum total of the house meters taken at any intervals, the engineer would be enabled to know the efficiency of distribution of his alternating current station, and to reckon out, not only the cost of the unit sold, but the cost of the unit generated, and to watch and know the effect of any improvements that are made in the transformers on the system.

It is only by adopting such methods of measurement that engineers in charge of alternating current stations will be able to remove the reproach which is sometimes hurled at them, that they have no means of measuring the energy or power they are supplying, or of knowing how much of what they make is sold.

In concluding this course of lectures I have to thank all those firms and gentlemen who have lent me the numerous instruments which I have been able to exhibit to you here. My endeavour has been to put the subject before you in as practical a manner as possible, and to give you, as it were, the cream of practical experience, rather than the skim milk of mere theory. It would have been difficult to do this without the practical exhibition of instruments of various types, and I do not think that any single instrument of practical importance has been mentioned an example of which has not been placed before you. The practical measurement of alternating currents may be more difficult, in many respects, than the measurement of continuous currents, but, at any rate, we have the satisfaction of knowing that it is now placed on an equally certain and satisfactory basis.

THE MUNICIPALITIES AND THE TELEPHONE.

The application of the Glasgow Corporation for a license to work telephones in their city (recently referred to in the *Times*) will probably oblige the Government to consider once more the whole question of telephone administration. This application is, indeed, but one of many indications that the public, and those most powerful representatives of the public, the municipal corporations, are at once tired of the present state of things and dissatisfied with the arrangements promised by the Government last year. Of the existing telephone service there seems to be but one opinion. Not only is it very dear, it is also very bad. While the annual rent of a telephone on the Glasgow exchange is £10, in Canada it is £4, and in Melbourne £6, while in Holland it varies from £6 to as little as £2 10s., and in Stockholm between £4 and £5 is paid for the power of conversing over a district 40 miles in length. But the quality of the service arouses still louder indignation. One Glasgow councillor, in the course of the recent discussions, said he had been trying to speak to a firm for more than a fortnight, and had not yet succeeded while another had given up the telephone because he was not prepared to use the bad language necessarily incidental to attempts to carry on a conversation. One cause of these difficulties is well known. Telephones can only be worked efficiently on a double-twisted wire, forming what is known by electricians as a completely insulated metallic circuit. The telephone companies have never thought fit to incur the expense of such a system, and the consequence is that talking over their wires in any large town is made vexatious, difficult, and sometimes impossible by the buzz of conversations on other wires. At the same time, the companies have consulted economy by running all their wires overhead, and thus covering every large town with a metallic web, harmless enough under ordinary conditions, but annoying to the householders whose chimneys and roofs are made use of, and occasionally in a peculiar state of the weather dangerous to life and limb. Moreover, this network of wires has been erected by companies possessing no statutory powers and without the leave of the municipal authorities. At a time when municipal life gains in vigour every year, such a slight has been deeply resented, and the National Telephone Company, which has now absorbed all rivals, has become unpopular with mayors, town councils, and town clerks. There is yet another drawback to the present system. The telegraph and the telephone ought to supplement one another. The telephone has the advantage of despatch and of being at hand when wanted: the telegraph excels in furnishing a written record of a message, in privacy, and in applicability to varying circumstances. There are many cases in which the two systems might be combined with advantage. A subscriber to an exchange may like a particularly important message to be delivered to his correspondent in writing, but at the same time it may be more convenient to him to use his own telephone than to send a telegram to a post office. There is no reason whatever why he should not speak his message to an exchange or a post office and have it delivered thence except that the telephones belong to a private company and the telegraphs to the State. If the company were allowed to deliver written messages, it would be for all purposes a telegraph company competing with the State, and, rightly or wrongly, the Government has thought it impossible to sanction such a competition. Hence the telephone has hitherto been used under limitations which go far to impair its usefulness, even had the mechanical arrangements of the telephone companies been what they ought.

Nevertheless, and notwithstanding these drawbacks, successive Chancellors of the Exchequer have been forced to lament a falling off in the telegraph revenue, and, suspecting the competition of the telephones to be one cause of this decline, the late Government determined upon the new departure explained in the Treasury minute of last year (House of Commons Papers, No. 229). These proposals reverse the policy of free competition initiated by Mr. Fawcett. They confine the telephone companies to certain areas, and reserve the rest of the country to the Postmaster General. In other words, while telephonic communication within towns—exchange business—is left to private companies, the Government proposes to take into its own hands all communications between town and town—trunk wire business. Trunk wires are to be open to all comers, and call offices, where persons not on an exchange may communicate with subscribers, are to be multiplied. At the same time exchanges and post offices are to be connected, so that telephonic messages may be spoken through to the post office, and thence transmitted as telegrams or letters. Moreover, the nuisance of overhead wires is to be checked by giving the telephone companies certain powers of laying underground wires.

In some respects these proposals (which of course can only be acted upon by agreement with the National Telephone Company) are an advance on the present system. It is something to establish public telephone wires from town to town and to combine the telephone service with that of the Post Office. But there are grave objections to the new policy. In the first place, it would secure the National Telephone Company in the enjoyment of a practical monopoly of telephonic communication in towns. The expressions of the Treasury minute on this head are clear:

"As to fresh licenses, no further license for the whole country will be granted; and even for a license to establish an exchange in a particular town no application will be entertained unless a formal resolution in its favour has been passed by the corporation or other municipal authority, and evidence given that there is sufficient capital subscribed to carry out the undertaking."

Now, it is obvious that if no further license for the whole country is granted, the company possessing such a license may safely defy any new local company, for, besides competing with it on its own ground, it will blackmail its subscribers when they try to communicate with other towns where exchanges of the one company which has a general license are established. In fact, then, the new arrangement would amount to a partnership between the Post Office and the National Telephone Company. Now, whatever may be said for or against a State monopoly, a monopoly in private hands, and used primarily to earn money for shareholders, is abhorrent to the sentiment of the present day. Nor is a partnership between the State and such a monopolist less objectionable. A partnership is only satisfactory where the partners have confidence in one another and work for the same object. The Government and the National Telephone Company would certainly not work for the same object while distrust and suspicion would as certainly take the place of mutual confidence. How can it be otherwise? The Government must before all things satisfy the public; the telephone company must before all things satisfy its shareholders. The Government is interested in earning a revenue from the telegraphs; the company has every motive for driving the telegraph out of the field. Neither the Government nor the company can ignore the possibility that some day the Postmaster-General may call upon the company to sell its enterprise. The company cannot but wish to enhance the value of the property it may have to sell; the Government cannot but wish to prevent any such increase of value. How is it possible that two such partners can work in harmony? Moreover, it seems probable that the partnership would be founded on a bad bargain for the Government. The Government is to take over trunk wire communication partly by purchasing the trunk wires of the company, partly by erecting new lines, and Parliament by the Telegraph Act of last year authorised the raising of a million of money for the purpose.

Suppose, when the million has been paid, the Government finds itself in possession of all the costly and unremunerative telephone business of the country, while the company is left in possession of that branch of the work which is inexpensive and profitable. Local letters and local telegrams are said to pay for those which travel far; but the State will have no local telephone messages, and though it will not be bound to uniformity of charge for long-distance work it will not be able to raise its charges indefinitely. And what complications may not arise between these suspicious partners as to the boundaries of towns and the distinctions between trunk wire and exchange business? Will not the company be the first to suggest to the inhabitants of a suburb that it is a monstrous thing that they should be compelled to pay a trunk wire charge for communicating with the exchange of the adjoining town? History will only repeat itself in such complaints. Anomalies of this kind obliged Mr. Fawcett in 1884 to abandon the principle of restricted areas and to give licenses for the whole country.

But these difficulties might for the present have been overcome, or at least overlooked, were it not for the question of wayleave. The telephone companies say they cannot get rid of the nuisance of overhead wires unless they are authorised to open streets and put their lines underground. So obvious is this conclusion that the recent Joint Committee of the two Houses appointed to consider how the balance might be held between the telephone companies and companies working electric tramways and railways went somewhat out of its way to recommend that "statutory powers be granted enabling telephone undertakers to lay their wires underground" (House of Commons Papers, 1893, No. 331). But to this the municipal corporations have the strongest objection, an objection recognised by the present law, which gives them an absolute veto upon the exercise of any such powers in their respective towns. They allege that to give a company which is in possession of a practical monopoly the right to take up streets without a concurrent obligation to supply the commodity in which it deals at certain rates and on certain uniform conditions is a departure from the best traditions of municipal government. They do not intend that the control of their streets shall be taken from them without some adequate consideration; and they have a strong dislike to the intrusion of a private company on any terms. It is to prevent such intrusion, as well as to deliver its citizens from the ills which they bear at the hands of the telephone company, that the Corporation of Glasgow has resolved, if possible, to take the supply of telephonic communication into its own hands; and there is much to be said for its proposal. If telephonic communication is not undertaken by the State, there is absolutely no reason why, if the ratepayers are agreeable, municipalities should not undertake the work. They already undertake the supply of water, gas, electric light, and the means of com-

munication by tramways; in fact, they undertake all enterprises which require the use of the streets. If telephonic communication can only be efficiently supplied by using the streets why should not the municipalities undertake that work also? The work they undertake they generally do well; they would probably do this work far better than any private company.

But there are two serious objections. One arises from the nature of the thing to be supplied. The telephone is used not only for speaking within the area over which the municipality rules, but for speaking to distant places with which the municipal authority has no connection. Assume that inter-town wires are in the hands of the Government; still, not only these wires, but the exchange wires of other towns, must be used. Every municipality, therefore, must agree with Glasgow in taking the telephone into its own hands—that is, it must carry on a commercial business at the risk of its citizens—or the telephone company will have to be dealt with; and that company will certainly know very well how to make charges and interpose difficulties which will still relegate the telephone millennium to a distant date. Still more serious is the difficulty arising from the fact that the telegraphs are in the hands of the Government. The telephone is only one kind of telegraph, and until both are in the same hands there must be competition between these rival means of communicating instantaneously with persons at a distance. It would be a misfortune to bring the State into competition with the municipalities; it would be a misfortune to place in many hands a business which should be in one. Parliament solemnly decided in 1868 and 1869 that the State should supply telegraphic communication. No one proposes to reverse that decision. As long as it stands it is an inconsistency to allow one very important species of telegraphic communication to be in the hands of private companies or local bodies. To levy a royalty upon other undertakers is not to undertake a business, and Parliament never authorised the purchase of the telegraphs merely to enable royalties to be charged and business to be *pro tanto* impeded and discouraged. The real lesson, therefore, of the proposal of the Glasgow Corporation is that the position created when licenses were granted to private telephone companies has become an impossible one. The advocates of the proposal have been careful to state that it is made only because the Government has made default in the work entrusted to it by Parliament, and by way of protest against the transfer of such work to private hands. The municipalities have no objection to the use of their streets by the Government; it is the intrusion of a private company to which they object. Let the Government take the telephones into its own hands and most of the difficulties vanish. A grievous mistake was made in not purchasing the telephone patents as soon as their value became apparent, and in creating a vested interest in a business which it had been deliberately decided was the business of the State. The public have said little about this mistake, because there has been a lurking suspicion that if the Post Office had acquired the telephone in early days very little more would have been heard of that wonderful invention. In these days of travel and communication the stifling of such an invention would have been impossible. But, however, that may be, the telephone has now established itself as a necessary adjunct of commercial life in England. The only question is, How can the public gain the greatest advantages from the instrument, having regard to the fact that the telegraphs are in the hands of the State? Many will hold the answer to be that the State should take the telephone also, even though it may have to pay somewhat dearly for past mistakes of policy. The alternatives are either to force the National Telephone Company into the streets of unwilling municipalities, or to bring these municipalities into the field of telegraph work as competitors with the State.—*Times*.

COMPANIES' MEETINGS.

DIRECT SPANISH TELEGRAPH COMPANY, LIMITED.

The ordinary general meeting of the shareholders was held on Friday last at Winchester House, E.C.

Sir John Pender, M.P., presided, and, in moving the adoption of the report, after expressing regret at the loss the Company had suffered by the death of their late chairman, Sir James Anderson, said that the accounts for the half year showed, after providing for debenture interest, a balance to the credit of profit and loss account of £4,645. The traffic receipts showed a decrease of £593 as compared with the corresponding period of 1892. The falling off in the receipts was chiefly due to the stagnation of Stock Exchange business in England, Spain, and France. It was somewhat remarkable that during the last six months, when things were at their very worst, submarine telegraph companies' shares stood a little higher in the market than usual; therefore, their position was sound. The working expenses were £130 in excess of those for the corresponding period of last year. The Company's cables, and the land lines in connection with them, had continued in good working order throughout the half year. The result of the half year's working was that, after adding the usual sum of £2,500 to the reserve fund, the balance of profit and loss amounted to £2,115. To that the Directors proposed to add £345 from interest on investments, and recommended the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 4 per cent. per annum on the ordinary shares. The reserve fund at the present time amounted to £35,936, £32,000 of which was invested and yielding them an average interest of 3½ per cent.

Mr. Edmund Ellinger seconded the motion, which was unanimously adopted.

LAMBETH.

At the last meeting of the Lambeth Board of Guardians the question of lighting by electricity was considered. It appears that some weeks ago the Guardians resolved to spend £30 upon obtaining the opinion of an expert as to the cost of lighting up the Lambeth Workhouse and Infirmary with electricity. Mr. Preece, an electrical engineer, was engaged to furnish the required information, and the following is the report he has addressed to the clerk on the subject:

"In accordance with the instructions contained in your letter of June 26 I have given careful consideration to the question of the lighting by electricity of the above-named buildings. In the consideration of such a question, naturally one of the most important points to review is the cost of the illuminant for which electricity is proposed to be substituted. In the case of the above-named premises this illuminant is gas. You have been good enough to supply me with the number of gas burners fixed, and the annual expenditure. The total cost during the year 1892 you state to be for the workhouse, £597. 13s.; for the infirmary, £1,047. 12s.—total, £1,645. 5s. But this is not all paid for gas used for lighting purposes; you also use gas for heating, cooking, and power. It is difficult without an intimate practical acquaintance with your heating and cooking appliances and the infirmary gas engine to determine what proportion of the total cost should be debited to these services, but an inspection of the appliances in question leads me to the determination that about £150 per annum will be the cost of the gas consumed in them, leaving in round figures £1,500 per annum as the actual cost of the lighting. I would further divide this sum between the two buildings as follows: workhouse, £550; infirmary, £950. The price paid is, I believe, 2s. 6d. per 1,000 cubic feet. We find thus that in the workhouse you consume 4,400,000 cubic feet, and in the infirmary 7,600,000 cubic feet of gas for lighting during the year. The number of burners in the workhouse is stated to be between 1,100 and 1,200. If we take the mean of the two figures (1,150) we shall probably be near the mark. Each burner therefore consumes 3,826 cubic feet per burner; while the 659 lamps in the infirmary consume on an average 11,530 cubic feet per burner. At five cubic feet per burner per hour it would appear that the workhouse lamps average 765 hours of lighting per annum; while the infirmary lamps burn 2,306 hours per annum on the average. I should judge from the inspection that I have made that we shall need to fix some 1,750 electric incandescent lamps of 16 c.p. or their equivalent in the two buildings under consideration: 1,000 will be needed for the workhouse, and the remaining 750 for the infirmary. We can safely afford to fix a less number of lamps than you have at present gas-burners in the workhouse; but the infirmary seems badly lighted in many of the rooms, and I think it would be wise to reckon on an increase in the actual number of electric lamps as compared with the gas jets now in use. With the easier manipulation of the electric light as compared with gas, we should get some reduction in the hours of burning. I will assume that the 1,000 lamps in the workhouse will burn an average of 700 hours per annum and the 750 lamps in the infirmary 2,100 hours per annum. The consumption of electrical energy on this assumption would be: in the workhouse, 42,000 supply units per annum; in the infirmary, 84,500 supply units per annum, total, 136,500 supply units per annum. The generating plant must be of sufficient capacity to maintain alight a large proportion of the 1,750 lamps at one time. I should assume that in no case would more than 1,600 lamps be lighted simultaneously. This would mean the employment of engines developing a total of 160 h.p. in their cylinders, and driving suitable dynamos to supply the lamps. At least one set of machinery must also be provided as a spare. I should propose on such an installation as this will be to fix three steam dynamo sets of 80 h.p. each. Two of these would supply the full load of 1,600 lamps, and one would only be run during the hours of lighter load (under 700 or 800 lamps), the third set being spare, but taking its turn regularly with the others as a working set. Two steam-boilers of large capacity would be needed. One of these would always be in reserve. The capital cost of the installation I estimate as follows:

Engines and dynamos	£2,100
Boilers	800
Steam pipes, pumps, and fittings	500
Lamp installation	2,625
Main cables	300
Contingencies	575
	say, £6,900

The working expenses would be:

	£	s.	d.
Cost of production at 2d. per unit	1,137	10	0
Maintenance of plant at 0·25d. per unit	284	7	6
Lamp renewals at 0·25d. per unit	142	3	9
	£1,564	1	3

say £1,600 per annum. To this sum must of course be added the interest on the capital expended, say, 3½ per cent. on £6,900 equals £241. 10s., bringing the total annual cost of the installation to £1,841. 10s., as against a gas bill of £1,500. *Per contra* to the increase in cost must be put the value of the better lighting in the infirmary. If only 600 lamps are fixed in the infirmary, giving a service about equivalent in lighting power to that now supplied, the annual cost will be reduced by £216. I have made no estimate of the cost of the structural alterations required to accommodate the machinery. I strongly recommend that if the work be

decided upon, that the two Galloway boilers that you contemplate fixing should be abandoned, and four new boilers of larger capacity be substituted for the boilers now in use. These should be worked together as one battery to supply steam for all purposes, including the electric lighting. The working pressure should be 120lb. to 130lb. to the square inch. It will be necessary to construct a new chimney for these boilers. This could be built upon the site of the present one, and the new boilers fixed in the same positions as the ones now in use. But a better arrangement would be to extend the boiler-room into the laundry by taking 16ft. off the end of the latter, which strip would include the site of the chimney. Under these conditions the chimney will have to be constructed on a new site outside. By following this latter course the extra space will enable us to fix four Lancashire (Galloway) boilers side by side. If only the present boiler space is available we shall have to fix economic or some marine type of boiler, which are not to my mind so satisfactory as the Lancashire type. Moreover, the heat of the stoke-hole, if placed central between two pairs of marine boilers facing each other, would be very great, and it would be difficult to get the men to work there. There will be no practical difficulty whatever in utilising a single battery of four boilers working at a pressure of 130lb. to the square inch on to the same range of steam pipes to generate all the steam you will need for all purposes whatsoever. An excellent position for the steam dynamo sets is the coal shed adjoining the laundry. This, I understand, can be spared. By utilising this shed for the purpose named you would have a nice compactly arranged plant, excellently situated for supervision, and at a fairly central point. There is no other position in the whole of your premises so well suited for the purpose. I am decidedly of opinion that an installation of electric light should be put in for your workhouse and infirmary. The extra cost over the present gas bill will be very small indeed, and your atmosphere will be saved from pollution. In the infirmary especially it will be found very much to aid your medical officers in securing that pure air so essential to the proper treatment of sickness, while in the workhouse the purer air of the rooms will certainly tend to improve the general health of the inmates.

It was moved and seconded that the Board should have nothing to do with the scheme, but this motion was lost, and an amendment postponing the matter for a month was carried.

GLASGOW.

The following memorandum has been issued with reference to the contract now in course of negotiation between the Post Office and the National Telephone Company, relating to the telephone system:

1. This contract is directly aimed against the corporations, county councils, and local authorities throughout the country.

2. All the telephone patents of importance have expired, which leaves the telephone service open, but it cannot be carried on without a license from the Postmaster to do so. Thirteen licenses were issued, all of which have now been bought up by, or are under the control of the National Telephone Company. They have by this means, therefore, re-established their monopoly, which formerly existed only by their possession of all the patents.

3. On the 23rd of May last the Treasury issued a minute setting forth the intended future policy of the Government with respect to the telephone system, and in this minute they stated that their object was to comply with the reasonable demands of any town or district for telephonic facilities, and to meet as far as possible the views of municipal authorities by placing additional telephonic facilities at the disposal of the public.

4. In order to carry out the policy of the minute, the Telegraphs Bill was introduced on the eve of the dissolution of last year, authorising the Treasury to apply one million pounds sterling for the purpose of buying the inter-town trunk lines and the erection of additional trunks. This Bill was referred to a Special Committee. After three sittings and hearing five witnesses, two of whom were from the Post Office and three from the telephone companies, they issued a special report. As the committee met on the eve of the dissolution, adequate examination and enquiry were impossible. The Treasury minute expressly sets out the intention of the Post Office to co-operate with and assist municipal and local authorities, but no witness was called by the committee from any corporation, county council, local authority, or anyone representing the telephone-using public. The committee, therefore, dealt only with one point—namely, the term of years for which the existing licenses had been granted, and they recommended that this should not be extended. In reference to other points and details about which, although they said they were of considerable importance, the committee made no report and gave no opinion, as they had heard no evidence, they said these might properly "form the subject of negotiations between the companies and the Department," and added a recommendation that any agreement made with the telephone companies was to be laid before Parliament.

5. The Act of last year went far beyond the policy indicated in the Treasury minute. By Section 5 the Postmaster may authorise any telephone company to exercise all the powers he has himself under the Telegraph Acts of 1863 and 1878. This is a direct attack upon the present position of corporations, no representative of whom had any opportunity whatever of considering the Bill. The Bill was rushed through in the last days of Parliament. Sir John Lubbock in the House of Commons, and Lord Hobhouse in the House of Lords, protested against the way in which it was rushed through, and pointed out that although the London County Council would be directly and seriously affected by the Bill, they had been entirely ignored and denied any opportunity of protecting their own interests.

6. In pursuance of the policy indicated in the Treasury minute the Corporation of Glasgow have applied to the Postmaster for a telephone license in order to establish a municipal telephone service. In their application they state that the Glasgow Corporation own their own street tramways, their gas and water supply and mains, their hydraulic power, also their electric light supply, and that no person or company except the Corporation, has any right to interfere with the streets of the city, and as an adequate telephone service must be laid underground, the control of such an undertaking should be in the hands of the Corporation, as the opening of their streets would interfere with their drains, sewers, hydraulic works, gas, water, and electric light mains and piping. The condition of Glasgow is entirely different from London and many other cities, inasmuch as the Corporation control and supply everything relating to public facilities, whereas in London these undertakings are all in private hands. The Glasgow Corporation in seeking this license is therefore carrying out the policy which they have always followed, and which has again and again been given effect to by Parliament, not only by the special legislation relating to the city itself, but in the general Acts for local authorities to establish gas, water, and electric lighting works, and to become owners of street tramways, etc., within their jurisdiction, as in their judgment a telephone service could be more properly supplied by the Corporation than by any private person or company.

7. The Glasgow Corporation being without any definitive reply from the Postmaster to their application for a license, a deputation from the Corporation had an interview with the Postmaster on Wednesday last, but could obtain no promise from him (a) to grant the Corporation a license to establish municipal telephones, or (b) to disclose the terms of, or to lay the proposed contract between the National Company and the Post Office on the table of the House before being ratified, as recommended by the committee which reported on the Bill last year, or (c) to consent to the appointment of a select committee of the House of Commons to enquire and report on the proposed arrangements between the Post Office and the telephone companies, and generally on the future policy of the Post Office with reference to the extension of the telephone service. The Postmaster informed the deputation that, before considering the question of any new licenses, he would conclude the agreement with the National Telephone Company for, amongst other purposes, the purchase of their inter-town trunk lines.

8. The National Telephone Company has absorbed all the other companies, and is now the only telephone company in active operation. The share capital is about £2,500,000 (not including preference and debenture capital). The particulars of how more than three-fourths of this £2,500,000 was appropriated can be ascertained from the prospectuses and amalgamation agreements of the National and the other companies.

9. The Postmaster therefore intends to conclude an agreement with the National Telephone Company which in its terms is certain to be an invasion of the rights, present or future, of the London County Council, and of every corporation in the country. Mr. Hunter, solicitor to the Post Office, told the committee that it is their policy not to limit the charges made by their licensees. The agreement will therefore practically make the Post Office and the National Telephone Company partners in the telephone service, and will debar any other service from being possible, and will enable the company to continue the present excessive charges in order to pay dividends and provide a sinking fund on, and for, millions of capital which are largely unrepresented by any property of any kind. On this point Mr. Lamb, of the Post Office, in his evidence before the committee last year (see Questions 123, 124 and 125), said that the National Company's capital might be taken at £4,000,000, that 19 years hence, when their license expired their existing plant would not be worth more than about £1,000,000; that they had no reserve fund, and that therefore they ought to be setting aside now a sum to place them in possession of £3,000,000 at the end of 19 years. This is the Post Office official's own statement as to the position of the National Telephone Company, and the sum of £3,000,000 can only be obtained by making excessive charges to the public.

10. In the Treasury minute of last year it is laid down that no license will be issued to any company unless it provides a double-wire service, without which no city can be adequately telephoned. Notwithstanding this, the Post Office are making a contract with the National Telephone Company, which has a single wire system, obsolete and worthless for modern telephony, and which has been condemned by the Post Office Department itself and by every writer on the telephone question. This will prevent any improvement of the service in the large cities. The National Company's system must be entirely reconstructed, further capital will have to be raised for this purpose, and the telephone-using community will be taxed to pay dividends upon it, the position of the telephone community being thereby made infinitely worse than it is at present. The service in large cities is not only condemned by every user, but is condemned by the National Telephone Company itself. The chairman of the company told the committee last year (see Question 366) that their company "had about 93 per cent. or 94 per cent. of the whole of the telephonic business of the country, and conducts a great deal of it monstrously badly," and further added, "take London for instance. London is very badly served." He ascribed this to want of statutory authority. The true reason is, that instead of applying the capital to provide an adequate

service, it was otherwise appropriated. If this company, without any statutory authority, raised and applied millions sterling to purposes other than those for which the company was expressly created, the question arises, how much would they have raised and applied in this way if they had possessed statutory powers? and assuming the contract is made with the Post Office, which will confer upon them a monopoly and a partnership with the Government, the further question arises, how much capital will they in the future raise for the same purposes, to which they have already applied about £2,000,000, all the accumulations of which are to form a tax on the community? The power and inclination to create promotion capital is as strong now as ever it was; indeed, a large sum was created last year in connection with obtaining the control of the New Telephone Company.

11. On account of the National Company interfering with local authorities establishing electric light installations or working tramways by electricity—because they might interfere with their obsolete single wire telephone service—a Select Committee of the House of Lords and House of Commons was recently appointed to consider and report whether the grant of statutory powers to use electricity ought to be qualified by any restrictions as to earth return circuits, or by any provisions as to leakage, induction, or similar matters, and if so, in what ways and under what conditions. The following recommendation is taken from their report: "The committee are of opinion that it is desirable in every way to facilitate the use of insulated metallic circuits for telephones, and for this end they recommend that statutory powers be granted enabling undertakers to lay their wires underground." In the above recommendation, the term "undertakers" is used in the same sense as in the Electric Lighting Acts, where the local authority is defined to come within the meaning of the term "undertaker," and preference is to be given to a local authority desiring to become an undertaker. This shows clearly that the Joint Committee carefully used words bearing this construction, and avoided those which might be construed to mean only the National Telephone Company, or any other private person or company.

12. The information is full and conclusive as to what an adequate double-wire underground service can be supplied for. In every European country which has not been hampered by such an organisation as the National Telephone Company, with enormous capital only in part represented by property, the telephone service is cheap and excellent. Many examples could be given, but it will be sufficient to refer to the telephone system of Stockholm, where the charge is £4 8s 11d. per annum, with a capital outlay of £2 15s 7d., which makes a total annual rental of less than £5. For this the subscribers have a right to speak within a radius of 70 kilometres, or nearly 40 miles. The Stockholm service is described by consuls and telephone engineers in the highest terms. The plant, both indoor and outdoor, is of the best description, and conversation is loud, distinct and free from disturbing noises. Full information in respect to the Stockholm telephones is in the possession of the Postmaster-General, who is therefore well aware of what can be done with perfect ease in our cities. No one would attempt to describe our present telephone service in the terms employed by those who have examined the system in Stockholm, and yet the charge in Stockholm is less than one quarter of that made by the National Telephone Company for its London service. The result of this is shown in the number of persons who use the telephone in Stockholm, as compared with those who use it in our own cities, which are shown in the following table:

	Population.	Telephone subscribers.			
Stockholm	228,000	8,400	1 subscriber to	27	of population
Glasgow ...	814,000	about 3,000	,,	271	,,
Manchester and Salford	703,479	,, 2,700	,	260	,,
Liverpool ..	517,951	,, 3,600	,,	144	,,
London ..	4,550,000	,, 7,000	,,	650	,,

13. To the London County Council especially the attitude and expressed intentions of the Postmaster are very serious. The Council has recently adopted the policy of northern cities, of controlling their own public undertakings, by purchasing the first section of their tramways, but instead of the Government through the Postmaster assisting London in the municipalisation of public undertakings, his intention is to shut them out from being able to deal with their telephone service for the whole 18 years for which the National Company's license has still to run.

14. Edinburgh and Aberdeen have also decided to apply to the Postmaster for a license to establish municipal telephones. Manchester and other cities are considering the question. A united movement is, therefore, possible, but London, as the capital, should take immediate steps to protect its own interests and join in what would then become a general movement. Meantime, Glasgow is entitled to look for the support of all the other corporations in obtaining a license to provide and work its own telephone service.

15. A grave crisis has thus arisen in reference to our future telephone system which demands the immediate and careful consideration of members of Parliament, of the London County Council and of all corporations and local authorities throughout the country, and unless steps are at once taken to prevent this proposed agreement being concluded with the National Telephone Company, local authorities will find themselves hampered in their work and the community saddled in perpetuity with a liability to pay charges calculated on the enormous capital created by the National Telephone Company, only a part of which has been expended on plant and property. It is therefore suggested that a joint movement should be at once organised with the object of defending the public rights.

BUSINESS NOTES.

Bradford.—The new electric fire alarms are doing good service.

Chatsworth House.—This establishment is now being equipped with an electric light installation.

Western and Brazilian Telegraph Company.—The receipts for the week ended September 1 were £2,725.

Direct Spanish Telegraph Company.—The receipts for the month of August were £214 more than for the corresponding period.

Eastern Telegraph Company.—The receipts for the month of August were £51,991, as against £49,069 for the corresponding period.

Lynn.—The Lynn Oil and Cake Mills Company are introducing, or about to introduce, the electric light throughout the mills and offices.

Shiplighting.—The "Glengariff," a new screw steamer, is lighted throughout by electricity, and is fitted with electric bells and telephones.

West India and Panama Telegraph Company.—The receipts for the two weeks ended August 31 were £206 less than for the corresponding period.

Aberdeen.—The Town Council have resolved to accept the offer of Messrs. John Blaikie and Sons to supply grip-boxes for the electric lighting, at a cost of £74 18s. 6d.

Salford.—A Local Government Board enquiry is to be held on the 19th inst. into the application of the Corporation for permission to borrow £50,000 for electric lighting purposes.

Derby.—The Town Council on Wednesday agreed to grant £100 5s. 4d. to the committee having charge of the Art Museum for the purpose of equipping it with the electric light.

Swansea.—The destruction by fire of a three-post standard of the National Telephone Company has caused considerable inconvenience to subscribers. The matter is expected to be remedied this week.

New Offices.—In consequence of the large amount of work in hand in the neighbourhood of Manchester, Messrs. Drake and Gorham have found it necessary to open offices at 100, King-street, Manchester.

Oxford.—The use of the electric light continues to increase. Trinity, Magdalen, and University College have introduced or extended it this vacation, and its employment in the town seems to be developing.

Worcester Tramways, Limited.—This Company has been registered with a capital of £12,500 in £1 shares to acquire, maintain, and work the tramways owned by the City of Worcester Tramways Company, Limited.

St. Pancras.—The Vestry are inviting tenders for the extension of the buildings at their electric light station in Longford-street, N.W. Full particulars will be found in our advertisement columns on page xvi.

Eastern Telegraph Office.—The Eastern Telegraph Company have opened a branch office at Winchester House for the acceptance of telegrams for South America, South Africa, Egypt, India, China, Australasia, etc.

R. Dawson, Limited.—The employes of this company recently took their annual beanfeast, proceeding to Windsor in four-horse brakes. The directors defrayed the whole of the expenses, and a very enjoyable day was passed.

Perth.—The Town Council have refused to give consent to an application by the Caledonian Electric Supply Company, Limited, to the Board of Trade for a provisional order authorising the supply of electric light to Perth.

Coast Communication.—Telegraphic communication is to be established between the Kentish Knock lightship and the Kingsgate coastguard station, which will then be connected by telephone with the telegraph office at Broadstairs.

Sale by Auction.—Particulars will be found in our advertisement pages of a sale by auction of manufacturing machinery and plant. The sale will take place at 80 and 81, Turnmill-street, on September 21. The auctioneer is Mr. J. C. Stevens.

New Lamp Company.—The British Volta Electric Glow-Lamp Company, Limited, has been registered, with a capital of £2,000 in £1 shares, to carry on the business of manufacturers of incandescent electric lamps and other electrical apparatus, and also to supply electricity.

Appointment.—The Gas and Electric Lighting Committee of the Burnley Town Council have decided to recommend the appointment of Mr. Francis Thurnfield, B.A., as electrical engineer to have charge of the electric lighting station in the borough, at a salary of £150 per annum.

City and South London Railway Company.—The receipts for the week ending September 3, were £745, against £737 for the same period last year, or an increase of £8. The total receipts for the second half year of 1893 show an increase of £446 over those for the corresponding period of 1892.

Position Vacant.—An engineer is required by Messrs. Norman and Son, Limited, of 137, Waterloo-street, Glasgow, to look after electric lighting apparatus consisting of Acme gas engine, dynamo, switchboards, incandescent and arc lighting, also hydraulic pumps and elevator. Letters to be sent to Messrs. Norman.

Holborn.—The chairman of the Holborn Board of Works on Monday switched on the electric light, which has been installed at a cost of over £400, to the large hall and committee room. Messrs. Verity and Sons, of Covent-garden, were the contractors for the work, which was carried out under the supervision of Mr. John Dyer, the firm's foreman.

Improved Telegraphic Accommodation.—The Great Eastern Railway Company have removed the telegraph office from the front of the Ipswich Station to a more commodious site on the up platform. The telegraph superintendent has made arrangements for the receipt of postal telegrams to all parts of the world, at all times of the day and night, Sundays included.

Balliol College.—We are informed that the contract for the lighting of this college at Oxford has been placed with Messrs. Drake and Gorham, and that 100 lamps are at present being installed. The hall being an exceptionally fine building, it has been decided to carry out the work in somewhat the same manner as at the Bank of England and the Inner Temple Hall.

Dover.—Replying to Councillor Mackenzie at a meeting, last week, of the Town Council, the Town Clerk said that the present position of the electric lighting proposals was that he was waiting to receive from the Brush Company a draft of the articles of association of the proposed company, and also a prospectus. As soon as he received them he would submit the matter to the committee.

Tenders.—The Secretary of State for Foreign Affairs has learned from her Majesty's Minister in Chili that the municipality of Santiago have expressed a wish to receive tenders for the lighting of that city by electricity. Such particulars as are in the possession of her Majesty's Government may be seen on personal application at the Commercial Department of the Foreign Office between the hours of 11 and 6 daily.

New Romney.—A disagreement between the Corporation of New Romney and the gas company as to the price has led the company to remove all public lamps, and the town is now in darkness. On Wednesday evening an attempt was made to light the streets with candles, but it proved a failure. Tenders have been received by the Corporation for an oil illumination. Why not for electric lighting?

Telegraphic Addresses.—Mr. Henry Sell has at last obtained permission from the Post Office to publish a complete list of registered telegraphic addresses. The list will be known, as heretofore, as "Sell's Directory of Telegraphic Addresses," and will contain nearly three times as many names as the previous volumes; in addition, each subscriber will be supplied with a quarterly supplement of corrections, etc.

Burnley.—The House Committee of the Board of Guardians have recommended the acceptance of the tender of the National Telephone Company at £22 for connecting the master's office with the porter's lodge, the casual ward, and the infirmary; and that the tender of the Oldham Boiler Works Company at £265 for the supply of a steam boiler for the workhouse be accepted. The recommendations have been approved.

Cleckheaton.—The National Telephone Company have addressed a circular to subscribers in Cleckheaton asking whether they would elect to be transferred from the Dewsbury to the Bradford district in the event of the choice being given, as recently suggested by the Chamber of Commerce. The circular intimates that in case of election to be transferred to Bradford the fee of 3d. per "call" to any place in the Dewsbury district will be charged.

Morley.—The Town Council have decided, on the recommendation of the Electric Lighting Committee, to advertise for schemes to be submitted for the electric lighting of the Town Hall and the borough generally, the competitors to show in detail two schemes—one for the lighting of the Town Hall, and the other for the lighting of such parts of the borough as the competitors might think a supply of electric light could be profitably given to.

The Royal Societies Club.—The applications for the membership in the Royal Societies Club now exceed 800, including 65 from members of the Royal Society (London and Edinburgh), and several from the Athenæum. The premises in St. James's-street which have been acquired for the clubhouse are being handsomely equipped, and will shortly be ready to receive members. Is any firm looking after the electric lighting of the building?

Lighting at Scarborough.—In our last issue we referred to the commencement in the supply of light by the Scarborough Electric Supply Company, and we are now enabled to give some particulars concerning the station. The boiler-house contains two boilers of 300 h.p., constructed to work at a pressure of 120lb. The dynamo room at present contains two alternators and steam turbines, and there is room for six more. The output of one dynamo is sufficient for energising 4,000 8-c.p. lamps.

Biggleswade.—Among recent contracts obtained by Messrs. Drake and Gorham may be mentioned that for the lighting of Old Warden Park, Biggleswade, for Major Shuttleworth. There will be installed 350 lights, and two 10-h.p. boilers will be fixed to supply two horizontal engines by Messrs. Clayton and Shuttleworth, and the current will also be used for driving a motor for pumping water to the house. This will dispense with the small engine now used for this purpose.

Portsmouth.—The Town Council have resolved to keep the account of the receipts and expenditure of the Electric Lighting Committee, both in respect of capital and income, entirely distinct from all other accounts of the Corporation, so that the financial result of the working of the electric light scheme may be clearly seen, and to have a statement showing such result prepared every six months by the borough accountant, and submitted to the Council through the Finance Committee.

Kendal.—At a meeting of the Town Council last week the Town Clerk said that Mr. Councillor Hargreaves had given notice of motion that a committee should be appointed to consider the expediency of applying for an electric lighting provisional order. Mr. Hargreaves had, however, had to leave the town, but he hoped that the Council would fall in with his suggestion, and appoint a committee of the whole Council to meet and confer on this question. The matter was deferred till the next meeting.

Falmouth.—The question of electric lighting has recently received the attention of the Town Council, and the Lighting Committee, of which Dr. Banks is the chairman, have been empowered to make enquiries as to the probable cost of lighting the principal thoroughfares by electricity. Messrs. Veale and Co., of St. Austell, had an exhibition of the electric light on Saturday near Market-strand from the premises of Mr. Joseph Grose, who is having his establishment illuminated by electricity.

Leeds Tramways.—Sir Douglas Galton has completed his award in the Leeds Tramways arbitration. He finds the value of the track at £58,000, on the basis contended for by the Corporation, and the total sum which the Corporation will have to pay for the undertaking, if the present award stands, is roughly estimated at about £112,000. If the basis contended for by the company be held correct, the value of the stock is assessed in the alternative at £119,000, against £152,900 originally claimed.

Worcester.—At a meeting last week of the Board of Guardians Mr. Blackford moved that the resolution of the Board adopting gas for the new workhouse should be rescinded, and that electricity should be adopted. It was pointed out that as the Corporation had promoted a scheme of electric lighting, and had resolved to adopt it for the city, it was the duty of the Guardians to further the interests of the ratepayers by having the light which was supplied by the Corporation. The motion was, however, not adopted.

Railway Station Lighting.—The Great Northern Railway are going to light their two principal stations in the London system by electricity—the stations at Finsbury Park and King's Cross. The current will be generated at large works the company have built at Finsbury Park, where they also manufacture compressed gas, and the current will be conveyed in cables to King's Cross Station. The cables are being put underground on the up line of metals, and are insulated so as to prevent induction in the telegraph or telephone lines alongside them.

Peterborough.—A special meeting of the Town Council is to be held on the 28th inst. to decide whether an application shall be made to the Board of Trade for a provisional order granting power to the Corporation to supply electricity within the borough. The borough engineer has been busily engaged for some time past eliciting information on the subject of the comparative cost of gas and electric lighting, and also as to the probable demand for the new light. So far as the principal tradesmen are concerned, there appears to be an almost unanimous desire in favour of the electric light.

Lighting at Windsor.—The *Windsor and Eton Gazette* invites the Town Council to at least "seriously consider the question of undertaking the electric lighting of the town, and if they will do so that will be one point gained. Then discarding all local and amateur ideas upon the subject we would suggest that they obtain the opinion of a first class practical electrician, as suggested by us on the 19th August, and abide by his recommendation. We are certain it would not take long for Mr. Preece, or any other practical engineer of experience, to demonstrate, not only the feasibility of carrying out the work, but of doing so at very little, if any, cost at all to the ratepayers so far as the rates are concerned."

Extension of the Telegraph.—Mr. A. Morley, in replying to Mr. Gibson Bowles, said the amount of guarantee that was required by the Post Office from persons who desired the postal telegraph to be extended to their neighbourhood, in cases where it was anticipated that the revenue from such an extension would be insufficient to meet the expenditure thereon, was made up of (1) interest at 3 per cent. on the outlay for poles, wires, and other materials and labour, and (2) an annual provision for the maintenance and the working of the telegraph. The guarantors were not required to pay the amount of the guarantee, but if the revenue in any year fell short of the amount they were called upon to pay the difference. Rural sanitary authorities could give guarantees.

Electricity and Sewage Disposal.—The drainage question has again been discussed by the Monmouth Town Council. The Mayor, referring to the visit to the borough of Mr. Beesley, civil engineer, of Westminster, said he was glad to see that in the plans submitted it was proposed to collect all the sewage by gravitation. As to utilising water as a motive power he thought that if they could get sufficient water power they might try an electrical installation. His opinion was that if they combined the two schemes—disposal of sewage and electrical installation—the profit of the one would pay the expenses of the other. It was decided to appoint a committee of five to deal with the matter, and to allow a sum of £10 for the purpose of obtaining the opinion of an electrical engineer.

Blackpool.—The central station of the municipality is approaching completion. Extensive plant has been put down under the superintendence of Messrs. Hammond and Co. at the station in

Princess-street. The current was switched on for the first time on the 31st ult., an effort having been made to have at least one section of the station at work by September. A 100 h p. engine was accordingly set at work, and many of the principal places of business, together with one large pleasure resort, employed the light for the first time, incandescent lamps, however, being solely used. The electric tramway in the town is worked from separate plant, also in Princess street, but it is proposed to produce the current for both operating the tramway and for illuminating purposes at the one central station, and it is probable that within a short time two more engines and dynamos will be put down at the new works.

Manchester Station. -Messrs. R. Hornsby and Sons, Limited, of Grantham, have just put down for the Manchester Corporation, at their central electric lighting station in that city, six very fine vertical compound tandem condensing steam engines. We understand that these engines are now running, and giving the greatest satisfaction They are very well proportioned and very massive in design, and run with the greatest steadiness. The governing arrangements are very perfect, and control the engines in the most efficient manner. The engines are designed to give 90 brake horse power when running at 120 revolutions per minute, and this they do easily. We are informed that Messrs. Hornsby have supplied a large number of engines for electric lighting purposes in various parts of the world The amount of money raised by the Corporation under the provisional order has been £50,200, of which £41,720 had been expended down to March 31.

Wrexham —At a meeting of the Town Council last week a letter was read from the Board of Trade informing the Council that the proposed revocation of the Wrexham Electric Light and Power Order, 1890, has been postponed for one year from August 14th. A letter was also read from Messrs. Lewis and Son, solicitors, stating that the Wrexham Electric Light and Power Company, Limited, were prepared, in accordance with the offer made by the chairman of the company to the Lighting Committee on April 25, to sell the provisional order for £500. Mr Benson moved, and Alderman Bevan seconded, that this letter be referred to the Lighting Committee Mr Owen proposed as an amendment that the Council sit in committee at the close of the meeting and consider the question. Upon a division the amendment was adopted by seven to six. It was eventually unanimously decided to call a special meeting of the Council in committee to consider the question.

Hastings. The Town Council have decided to grant a license to the National Telephone Company to lay telephone wires in tubes underground. The Electric Lighting Committee reported last week that they had received a letter from the secretary of the Hastings and St. Leonards on Sea Electric Light Company, Limited, intimating that his directors were unable to obtain the necessary transformers required to complete the installation of the extended electric lighting of the front line by the 1st October next, the time fixed by the contract for the commencement of the lighting, and that the contractors would not bind themselves to deliver the apparatus by any fixed date, and applying under the circumstances, for the time for the commencement of the additional lighting to be postponed until the 25th March next, by which date the directors hoped that the machinery might be duplicated, so as to render the lighting certain and efficient The committee recommended that the application should be granted, and this was agreed to by the Council.

Lighting at Hull —The time for completing the contract for laying down the mains for supplying the electric light outside the Old Town has not yet expired, but the work has been done so speedily by Callender's Company that it is practically ready for intending users to have a supply of light. The first installation was started on the 30th ult. on the premises of Messrs. Turner and Drinkwater, photographic artists, Regent's-terrace, Anlaby road. In celebration of the switching on of the current a reception was held at the studios, the guests being welcomed by Mr Charles Turner. There were also present Mr. Lewis, the electrical engineer, who has been so far responsible for the works at Hull, but who is now leaving for Wolverhampton this week; Mr Gibbon his successor; Mr. C. A. Baker, the resident engineer of Messrs Callender's Company, and others interested in electric lighting The actual switching on of the light was accomplished by one of the young ladies present. Not only the studios, but the dressing rooms are most elegantly fitted up and decorated, the latter being in Louis XVI. style, and when viewed by the new light the whole presented a very charming appearance. The light has been fitted up all over the premises, and can be utilised for many purposes. The installation has been carried out by Messrs King and Co., of Market place, Hull.

Telephony at Aberdeen — The Town Council of Aberdeen, similarly to those of Glasgow, Edinburgh, Manchester, and elsewhere, are moving in the matter of municipal telephony. When the members of the former body met on Monday, a resolution was moved by Mr Scott that a remit should be made to a committee to consider and report as to the advisability of the Town Council establishing a telephone service He said that the subject was a proper one for enquiry by municipal corporations, and that it had been found that the telephone system was so much a matter for the public benefit that it was a proper subject for control by a public body He thought it should be left for the committee to say whether they thought the system should be under Imperial or municipal control, and this was agreed to. He asked that the committee appointed to consider and report on the question should consist of the Lord Provost, Bailie Lyon, Bailie Mearns, convener of the Streets and Roads Committee; Treasurer Bisset, Mr. Farquhar, convener of the Gas Committee; Mr. Bain, convener of the Water Committee; Mr. Gordon, convener of the Sewerage Committee; and himself. Treasurer Bisset seconded the motion, and after some discussion the subject was remitted to the Finance Committee. It is proposed to send a deputation to London to interview the Postmaster General and others.

Dorset. -On Tuesday, at a meeting of the Town Council, Mr. Gregory enquired whether the report which Mr F M Newton, of Taunton, had been commissioned to prepare upon the best means of lighting the town by electricity was yet forthcoming. It was four months since the order was given to Mr Newton, and if a report could be furnished it should have been sent by this time. The clerk said that Mr. Newton wrote on the 16th ult. expressing his regret that there had been delay in the presentation of his report. The matter had, however, been receiving his attention, and he had thought it advisable to call in an expert in hydraulic engineering to assist him by a survey of and report upon the water power which might be available. He visited Dorchester with this gentleman, and had his report now before him. He should forward his own report to them on Monday next, when he hoped to be able to submit a scheme which would recommend itself to their Town Council. Mr. Symonds said that as he did not receive the promised report on the day mentioned, he wrote to Mr Newton again, and on the 1st inst. he received another letter from him, stating that he had the scheme ready with the exception of certain particulars of cost of the cables which were being prepared for him by a leading London firm. These were promised to him in a week's time, the head of the firm in question being unable to promise them sooner. Until he received these particulars it would be impossible for him to fulfil that part of their instructions referring to the cost at which they could supply current to private consumers.

Torquay. The Torquay Town Council on Tuesday again considered the proposal to light the town with electricity. The Electric Lighting Committee reported the result of some correspondence between the town clerk and Mr Trentham, electrical engineer. It appeared that the latter estimated the cost of the electric current at 6d per unit, which was at the same rate as gas at 1s. 5d per 1,000ft, or, when economised by turning out lights not actually required, 3s. per 1,000ft. Details were given as to the cost of the various systems suggested. Mr Trentham maintained that the high pressure system was the best for Torquay. The committee accordingly recommended that the town clerk should ascertain Mr Trentham's terms for preparing the necessary specifications and drawings, and otherwise prepare to proceed with the carrying out of the scheme. The estimated cost of the works was £17,403, maintenance £3,100, and annual revenue, at 6d per unit, £3,320. The Mayor moved the adoption of the report, saying the time had now arrived when the committee should be instructed to go forward Mr Harrison seconded the motion Mr Swift Evans proposed as an amendment that the scheme be postponed for a year. He did so on the sole ground that the Council had already sanctioned work of the value of £11,000, which would raise their debt to £360,000. It was also well known that another claim for £35,000 would be before them shortly, and if that was admitted their debt would amount to £15 per head of the population He thought it was quite time some of them put a stop to the increase of the debt Mr R Crocker seconded and spoke of the scheme as a wild speculation At the suggestion of Mr R Crocker, the amendment was altered to postponement for six months, and it was carried

Municipal Corporations and Telephony —A committee of the Association of Municipal Corporations have been strenuously putting forward arguments in favour of discussing the telephone question with the Postmaster General, and the latter has now made arrangements for an interview to take place after the parliamentary recess. The association on July 27, after considering the report of the Joint Committee on Electric Powers, adopted the following resolution: "That in the opinion of this council no statutory powers should be conferred on telephone undertakers unless statutory obligations and limitations are imposed on the undertakers, and that the Special Committee be requested to consider, as soon as possible what these statutory obligations and limitations should be, and, if they think it advisable, to have an interview with the Board of Trade on the subject." The Special Committee of the association met on the 3rd ult for the purpose of considering and giving effect to this resolution, when it was determined that the secretary should be requested to ask the Board of Trade and the Postmaster-General to receive the members of the committee, and to discuss the important recommendations contained in the report of the Joint Committee with regard to conferring statutory powers on telephone undertakers. On the 9th ult, a deputation of members of the committee had an interview with Sir Courtenay Boyle at the Board of Trade, and explained the views entertained by the council of the Municipal Corporations Association as expressed in the resolution Sir C. Boyle then suggested that the deputation should communicate with the Post Office Department on the subject. They accordingly attended upon Mr Lamb, assistant secretary, at the General Post Office, St. Martin's le Grand, to whom they repeated their explanations As a result of this conversation, application was made to the Postmaster General for an interview, so that the subject might be fully presented to him by a deputation on behalf of the Municipal Corporations Association, and, as already mentioned, the Postmaster-General has now decided to receive the deputation.

Lighting at Whitehaven.—The central station at Whitehaven was formally opened on Saturday, the 2nd inst, by Miss Dees, daughter of Mr J. Gibson Dees, J.P., chairman of the Whitehaven Town and Harbour Trust. The order under which the electric

lighting works at Whitehaven have been laid down was obtained in the session of 1891, the area of supply being the whole of the urban sanitary district. In the summer of 1892 steps were taken by the trustees for putting their powers under the order into effect, and the advice of Dr. John Hopkinson, F.R.S., was obtained. Dr. Hopkinson recommended a scheme by which the whole of the public street and harbour lamps should be lighted by means of incandescent lamps, and that sufficient plant should be provided for supplying electrical energy to a few of the principal streets for private consumers, in addition to the street lighting. Dr. Hopkinson was thereupon retained by the trustees to prepare plans, etc., for a plant equal to an output of 165 kilowatts, including four sets of Willans compound central valve engines of the FF type, coupled direct to Crompton dynamos, each giving 150 amperes at 240 volts, and a battery 106 E.P.S. K type cells, with a normal output of 100 amperes at 212 volts. The system of supply is the three-wire for domestic lighting, and two-wire at 230 volts, for public lamps, which comprise incandescent lamps run two in series. The cables have been supplied and laid by Messrs. Siemens Bros. and Co., Limited. Steam is generated at a pressure of 120lb. per square inch by two Lancashire boilers supplied by the Lowca Engineering Company, Limited, Whitehaven. The current was switched on by Miss Dees, and after the ceremony the trustees and the contractors' representatives and a few of the chief officials of the trust were entertained by Mr. Dees at the Town Hall. The work has been carried out from its commencement under the supervision of Mr. C. H. Wordingham, A.M.I.C.E., of Dr. Hopkinson's staff, Mr. F. Budd, the representative of Messrs. Siemens Bros., being the contractors' engineer for the cable laying, Mr. J. A. Montealegri representing Messrs. Crompton and Co., while Mr. Harry A. Sharps represented the Electrical Power Storage Company.

Lighting at Bandon.—At the monthly meeting of the Bandon Town Commissioners, Mr. C. Crowley (chairman) presiding, Mr. Scanlan, solicitor, said that he was instructed to take the opinion of Mr. Lawrence, B.L., on the subject of the Commissioners' opposition to the provisional order sought by the Bandon Electric Lighting Company, to authorise them to supply electricity for public and private lighting and other purposes. The result of the opinion they were already aware of, as it had been already made known to them. He presumed it would be taken for granted that Mr. Lawrence was sufficiently capable of advising them as to what they should do. Acting on Mr. Lawrence's instructions, he drafted the special notice announcing that this subject would be specially considered at the meeting, and he also wrote to Mr. G. K. Sherlock, solicitor to the electric lighting company, enclosing a copy of the circular, and inviting him or the promoters to appear there and state their case. On the 2nd September he received this reply from Mr. Sherlock: "I am in receipt of yours of yesterday, enclosing circular convening a meeting of the Bandon Town Commissioners for Monday, the 4th inst., to consider my notice of the 1st July, 1893, and inviting the promoters of the electric lighting company to attend said meeting to make their case to the Commissioners. In reply, I beg to state that the proper course would be for the Commissioners to appoint a committee for the purpose of meeting the promoters or a committee thereof for the purpose of properly discussing the object in all its bearings. In this way the matter can be much more satisfactorily discussed than the course you suggest, and your committee would, of course, make a report thereon to their Board for adoption or otherwise. This is the course the Guardians adopted, with the result you are aware of. I believe the adoption of the electric light in this town would be greatly for the benefit of the ratepayers, as well as the consumers generally, and the company are perfectly willing to discuss the matter with any committee that may be appointed, which I cannot but think would be attended with most beneficial results to our town in every respect." With reference to this he (Mr. Scanlan) wrote: "I am in receipt of yours of yesterday on the subject of the Bandon Electric Lighting Company and Bandon Town Commissioners, and I note your suggestion as to the advisability of a committee of the Commissioners considering this matter. I am in a position to say that the Commissioners most carefully considered the procedure they will adopt in discussing the question, and that they had been furthermore advised by counsel on the subject. I cannot therefore see that my clients should adopt your suggestion, which, however, should be made to them directly, as I have no authority to act otherwise than they have determined on. The course followed by the Board of Guardians cannot, in my opinion, be taken by the Commissioners as a precedent, for the simple reason that whereas only a very small portion of the Bandon Union is included in the proposed area, the whole of the town of Bandon is included, and hence each commissioner is probably interested. This would, therefore, involve the necessity of having the whole Board of Commissioners on the committee." He had taken it on himself to reply thus, as there was no meeting of the Commissioners under which he could bring the matter under their notice. The meeting being convened in the manner suggested by counsel, it was for it to consider what should be done. Mr. Foley proposed that they oppose the granting of the provisional order, and in doing so he wished to make a few remarks with regard to this electric lighting company. The object of that company was, according to its memorandum of association, to promote another company to purchase themselves, with shares in the new company to be floated, so that in all probability they there in Bandon were in the commencement of a number of limited liability companies. After considerable discussion it was resolved to carry out the recommendation of the ratepayers to reject the scheme, and to oppose the application of the company to the Board of Trade.

PROVISIONAL PATENTS, 1893.

AUGUST 28.

16168. **Improvements in arc electric lamps.** William James Davey, 161, Huddleston-road, Tufnell-park, London.

16175. **Improved method of fixing metal parts of electrical fittings to porcelain or other refractory substances.** Andreas Peter Lundberg, 18, Regina-road, Tollington-park, London.

16197. **Improvements in electric traction apparatus.** Paul Schoop, 28, Southampton-buildings, Chancery-lane, London.

16205. **A novel construction or arrangement of electrical resistance coil and in appliances therewith for determining the amount of current passing through said coil.** Arthur Chester and John James Rathbone, 106, Fleet-street, London.

AUGUST 29.

16226. **Improvements in electric cars.** Ernst Egger, Ferdinand August Wessel, and Aaron Naumburg, 57, Barton-arcade, Manchester. (Complete specification.)

16265. **Improvements in electrodes for secondary voltaic batteries.** Gustave Philippart and George Lentz, 28, Southampton-buildings, Chancery-lane, London.

AUGUST 30.

16307. **Improvements in electric meters, dynamos, electrolysis of solutions, manufacture of sodium and sodium substitutes, manufacture of potassium cyanide, gold extraction, and recovery of tin from scrap.** James Swinburne, Broom Hall Works, Teddington.

16312. **Improvements in conductors and arrangement thereof for distribution of electrical energy.** George Wilkinson, Mansfield House, Southport.

AUGUST 31.

16389. **Improvements in electric heating apparatus.** James Finney McElroy, 4, Corporation-street, Manchester. (Complete specification.)

SEPTEMBER 1.

16480. **Improvements in or connected with electrically-propelled boats.** Korbey Daveron Bowen, 47, Lincoln's-inn-fields, London.

16483. **Improvements in and relating to electric switches.** Hippolyte Charles Chocquel, 45, Southampton-buildings, Chancery-lane, London.

16484. **Improvements in self-starting alternating-current electromotors.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Francis Henry Sleeper, Canada.)

SEPTEMBER 2.

16514. **Improvements in incandescent electric lamps.** Edwin Charles Lacey and William Habgood, 121, Knight's-hill-road, West Norwood.

16562. **Improvements in electric motors.** Benjamin Willcox, 47, Lincoln's-inn-fields, London. Ernest Richard Esmond, United States. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1892.

14567. **Cases for electric cables.** Hindley.
16570. **Electrical propulsion of vehicles.** Elmore.
16866. **Secondary batteries.** Miller.
17287. **Electric gas-lighting apparatus.** Hamer.
17304. **Electric switch.** Loch.
17855. **Electrical distribution.** Tomlinson.
18037. **Electric welding apparatus.** Mountain.
18359. **Electric regulators.** Davis.
18878. **Electrical switches, etc.** Taylor and Tunnicliff.
22923. **Electric cables.** De Ferranti.

1893.

13279. **Telephones.** Seiffert.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
Pref.	—	2¾
City of London	—	11
— Pref.	—	12¾
Electric Construction	—	—
Gatti's	—	5¼
House to House	5	5½
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	6½
National Telephone	5	4½
St. James', Pref.	—	8
Swan United	3¾	3¾
Westminster Electric	—	5½

NOTES.

Theatre - Lighting.—The electric light has been installed in the auditorium of the Comedy Theatre.

Large Gas-Engine.—A large tandem gas-engine, indicating 200 h.p., has been laid down at Swansea.

Lighthouse Communication.—The works recommended by the Royal Commission on Electrical Communication with Lighthouses will cost £10,000.

Laundry Appliances.—Electric power is being used to operate various laundry appliances at the exhibition now being held at the Royal Agricultural Hall.

Value of the Telephone.—Another instance of the importance of the telephone to the police in effecting the capture of criminals has been illustrated in Edinburgh.

Iron and Steel Institute.—The autumn meeting will be held at Darlington on the 26th, 27th, and 28th inst. Various papers will be read and visits paid to different works

Moulded Casing.—We have received a sample of the moulded casing made by Messrs. J. M. Bennett and Sons, of Ardwick Station, Hyde-road, Manchester. It is termed the "Goehring" casing.

Personal.—Mr. F. E. Baines has just retired from the postal service through ill health. He was a well-known and able official, and while Surveyor-General for Telegraphs he displayed great energy in developing the system.

Newport.—The Chamber of Commerce have resolved to support the motion to be brought forward in the House of Commons by Mr. Henniker Heaton relative to the improvement of the postal and telegraph services.

Refuse Destructors.—The refuse destructor in the Powderhall district of Edinburgh, and referred to in our last issue, was inspected on Monday by the magistrates and Town Council, and the electric light plant was set in operation.

Traction at Halifax.—A company has approached the Town Council with a view to obtaining consent to the erection of overhead wires for working an electric tramway. The subject was discussed by the Council on Tuesday and was adjourned *sine die*.

Another Professor.—According to a recent decree of the French Government, following on a report of the Minister of Public Works, a professional chair of applied electricity has been created at the Ecole Nationale des Ponts et Chaussées, Paris.

Cassel.—We have received a copy of a reprint of an article from the *Elektrotechnische Zeitschrift*, describing the electricity works at Cassel, and which were designed and carried out by Mr. Oscar von Miller, of Munich. This station was referred to in a previous issue.

Glasgow.—The municipality work the passenger boats on the river and charge a fare of 1d. for any distance. They propose to introduce the same charge on the tramways, when the latter come into their possession next year, and when it is hoped a decided move will be made in electric traction.

Long-Distance Telephony.—As mentioned in our last issue, the telephone service between Christiania and Stockholm, a distance of about 350 miles, was opened on the 2nd inst. by the King at Stockholm and the Norwegian Premier, M. Stang, at Christiania. The telephone works exceedingly well.

British Museum.—The lighting by incandescent lamps of the desks in the large reading-room, referred to in our last issue, has now commenced. There are about 200 lamps, and from eight to ten lamps have been provided for each desk. The light is greatly appreciated by readers frequenting the room.

Photographic Society.—A congress of the Photographic Society of Great Britain and affiliated societies will take place on the 10th, 11th, and 12th prox. The thirty-eighth annual exhibition of the former society will be held from 25th inst. to November 15, at the gallery of the Royal Society of Painters in Water Colours, 5A, Pall-mall East. The offices of the society are at 50, Great Russell-street, Bloomsbury, W.C.

New Stations.—We understand that Prof. Kennedy has prepared a specification for the Sunderland station, and that the central station at Oldham is half finished, the machinery having already been tested. At Aberdeen the buildings are practically complete, the plant has been ordered, and the mains are nearly all laid, whilst at Belfast the site has been decided upon, and it has been decided to make a gas-engine installation. A scheme is being thought out for Edinburgh.

Of All the Sorts of Saws.—Some enterprising genius, says the *Chemical News*, with an eye to novel effects has been trying a form of "electric saw," which is composed of a platinum wire heated by means of an electric current passing through it. The hardest wood, it is said, can thus be cut. After finding that red-hot platinum wire was liable to break, the experimenter next tried steel wire, platinised by immersion in a solution in ether of platinum chloride.

Shiplighting.—The "Devastation," after undergoing a thorough renovation and reconstruction in hull, machinery, and armament at Portsmouth, has undergone her eight hours' steam trial under natural draught. The ship has been furnished with a modern installation of electric lights, with larger dynamos and fresh leads, and the entire electrical equipment has been brought up to current requirements, including the firing gear, bells, submarine torpedo apparatus, and search-lights.

Telephony between Vessels.—The Kansas State University authorities at Topeka have perfected a telephone system which can be used for communication between vessels at sea. Experiments made in the Atlantic Ocean during the summer months show, it is said, that the system can be worked successfully, and that it will be of great service to the shipping community. For instance, it is submitted that incoming vessels will be able to report at New York 24 hours earlier than is the case at present.

Lighting at Bristol.—The municipal central station has now practically been completed, and in the course of two or three weeks lighting will commence. Most of the principal thoroughfares of the town are to be illuminated by arc lamps of 1,500 c.p., and the applications for private installations are very numerous. The Town Council has adopted the alternate-current system, with 11 transformer sub-stations. The central station has cost £23,000 to construct, apart from the plant laid down, and the total cost of the station has been £82,300.

The Theatrophone.—A reception by the Institute of Journalists is to be given on Thursday next at the Imperial Institute. In the side galleries the telephone is being specially fixed so that it will be in communication not only with London, but also with the chief provincial cities. The electrophone will accommodate 100 people at a time to hear the performance simultaneously in progress at some half-dozen London and two or three provincial theatres; and if the authorities of the General Post

Office will lend their Paris wire, also with the Paris Grand Opera House.

Mathematical Instruments.—The new catalogue just issued by Mr. W. F. Stanley, of 4 and 5, Great Turnstile, Holborn, W.C., contains particulars and illustrations of mathematical drawing, and surveying instruments made by this firm. Mr. Stanley keeps in stock every article required by architect, engineer, or draughtsman. Among the various appliances may be mentioned magnetic compasses, mine surveying instruments, drawing instruments, cameras, lenses, and photographic apparatus generally. Of electrical apparatus, there are batteries, lamps, galvanometers, Ruhmkorff coils, vacuum tubes, induction machines, etc.

Blowing Hot and Cold.—The *Pall Mall Gazette* of Monday states that "there is hope that in time the eyes of the public may be opened to the futility of buying quack remedies simply because they profess to be electrical, and therefore mysterious. . . . . The chief offenders in America, as here, are electric belts, electric hairbrushes, and electric headache cures. There are also electric smelling-bottles, corsets, tabloids, mixtures, and articles of every kind to which the word can be applied." Yet on another page our contemporary prints an advertisement relating to "electropathic" belts, which it has condemned in the preceding lines! Do be consistent.

Toynbee Hall.—A prospectus of the Toynbee Hall Electrical and Chemical Societies, Toynbee Hall, 28, Commercial-street, London, E., has been forwarded to us. The object of the society, of which Mr. W. H. Preece is president, is to provide for skilled mechanics, manufacturing chemists, and others who from the nature of their work are interested in electricity and chemistry, societies for practical experimental work, the reading and discussion of papers, etc. We understand that there are already 36 members of the electrical society, and 16 members of the chemical society. The honorary secretary, at the above address, will furnish any further information.

Water Power.—A syndicate which was formed in 1891 at Saint-Etienne to utilise the falls of the Loire for the electrical transmission of power, obtained last December a concession for the supply of electricity in that town. As a commencement, preparations are now being made for the utilisation of the water power of the Forey Canal to the extent of 600 h.p., and ultimately a branch of the Loire will be used for the production of electric power. Triphase machines will be laid down, and the arrangement will be such that they will be operated either by the turbines or by steam power. The generating station is situated at the Chatelet, near Saint-Victor-sur-Loire.

Manchester Technical School.—In the syllabus just issued of the Municipal Technical School, we note that a third year's course has been added for day students of electrical engineering, and additional facilities are offered for practical instruction in experimental mechanics, whilst in the evening a preliminary course is arranged in electric lighting and transmission of power for beginners, together with a course in electrical calculations. The demand for instruction in the subjects embraced in the department of electrical engineering has induced, as mentioned a short time ago, the committee to appoint a third lecturer—namely, Mr. B. B. Skirrow, M.A., of Mason College, Birmingham.

Electrical Purification of Mercury.—In the *Annalen fur Physik und Chemie*, M. Jaeger gives the details of a method by which mercury can be purified electrically. Briefly stated, the system involves the following procedure: The ordinary mercury of commerce is first distilled *in vacuo* in a specially devised appliance absolutely free from oil or grease, and in the making of which great care has been exercised to keep from using grease or indiarubber. The mercury is then converted into a nitrate, and reduced electrolytically from a solution of that salt. A platinum sheet is used for the cathode, and distilled mercury for the anode. A current of from one to three amperes proves sufficient for the purpose, giving a current density of ·004 to ·012 ampere for the cathode, and ·001 to ·003 for the anode per square centimetre.

Sample Museum.—The Foreign Office have informed Mr. Calvert, secretary to the Leeds Incorporated Chamber of Commerce, that Germany and Austria-Hungary some time ago established in Bulgaria a commercial museum for samples of their respective manufactures, and that Belgium was about to establish a similar depôt. M. Boschau, of Sophia, now proposes to establish a museum for samples of British manufactures. The Earl of Rosebery suggests that the Leeds Chamber of Commerce, or individual firms who might wish to send samples or to have further particulars of the scheme, should communicate direct with M. Boschaü. The list of manufactures likely to find a ready market in Bulgaria includes machinery of all sorts, steam engines and boilers, motors (1 h.p. to 25 h.p.), locomotives, gas-motors, cranes, drilling machines, electrical machines and instruments, agricultural machines, etc.

Automatically Showing a Rise of Temperature. With the idea of giving notice in good time of any rapid increase in temperature of a room or building, such as might arise from fire, a German firm is introducing upon the market an appliance depending upon the expansion of air in a closed space. It consists of a small cylindrical box, the bottom and sides of which are formed of thick nickel sheets, but the top is covered with a very thin disc of the same metal. With any increase of temperature in the room where this apparatus is fixed the air expands inside the box, and forces up the thin metal cover until a platinum button, soldered on the upper side at the centre, comes into contact with a screw terminal, and so completes an electrical circuit by which a bell may be rung or an alarm otherwise given. The device is old enough, but still has the great advantage of simplicity, and is worth reviving for that reason.

Gas Boiling Burner.—A new type of "gas boiling burner," made of cast iron, has been brought out by Messrs. Fletcher, Russell, and Co., Limited, of Thynne-street, Warrington. The surface of the burner has been treated by a new process which is said to entirely prevent rust, and which allows of a wide range of decorative effect. The method is termed the "Chimatto" enamelling process. The film of enamel is so thin that the most microscopic details on the metal are unchanged. We understand that all colours, the most delicate tints in any number, either dead or bright, and both gold and silver, also either dull or polished, are obtainable on the same casting, and that all alike are unchangeable either by exposure to air or to any heat up to a bright red. The application is new, and admits of a large extension for permanent decorative work of all kinds; castings protected in this manner are said not only to be capable of fine artistic treatment, but they are also absolutely permanent and proof against dirt and smoke.

Electric Tramway Accessories.—In the new catalogue issued by Mr. R. W. Blackwell, of 39, Victoria street, Westminster, S.W., attention is directed to the line material and special appliances for electric tramways manufactured by Messrs. A. and J. M. Anderson. Special consideration is devoted to the "Aetna" insulators, which ensure high insulation and economy of power, and to the "Aetna"

insulating material. The latter is composed of ingredients which in a plastic state form a homogeneous mass which is readily moulded under pressure. The finished product is strong, durable, and non-absorbent, and is impervious to water and weather. It is especially adapted, either by itself or in combination with metal or other parts, for use in trolley wire hangers, span or guard wire insulators, arc lamp hangers, etc. Various illustrations are given of different insulators, single and double curve pull offs, strain insulators, heavy terminals, trolley wire ears, the "Boston" trolley pole and wheel, and trolleys, etc. Among other appliances dealt with are the "Ajax" lightning arrester, wire-stretching machines, track drills, bond bending machines, etc. We understand that these appliances have received the highest approval of practical tramway constructors and operators.

Post Office and the Telephone.—The Postmaster-General's annual report on the Post Office, issued on Wednesday, states that as regards telephones, the Telegraph Act, 1892, authorises the loan of £1,000,000 sterling for the purchase of the trunk lines of the companies, and for the construction of a Government system to connect the business centres of the kingdom. The negotiations have been carried on with the companies for the purpose of arriving at an understanding as to the areas within which their operations are to be conducted. The Department has proceeded with the erection of trunk lines between Leeds and Hull, London and Brighton, Swansea and Cardiff, Cardiff and Newport, Newcastle and Hexham, Newcastle and Morpeth, and Glasgow and Belfast. The trunk line between Glasgow and Belfast was opened for traffic in May. A main trunk line is at present under construction from London to Glasgow, passing through Nottingham, Sheffield, and Leeds. Branch lines will be erected from Nottingham to Derby and Leicester, and from Leeds to Manchester and Liverpool. The entire system will consist of metallic circuits, and when completed will enable each of the towns to communicate direct with London, or with each other.

The Tramway Congress.—The Congress on Tramways at Pesth, and to which reference was made in our last issue, was well attended, and no less than 60 delegates from foreign countries (including representatives from Germany, France, Belgium, Italy, Switzerland, Denmark, Sweden, Norway, and other countries) were present. M. Michelet, of Brussels, the president of the congress, mentioned that the tramway system of Budapest was already in an advanced condition, there being four different systems in active operation. These are—the ordinary tramways; the electric tramway, which runs through the greater portion of the city; the cog-wheel railway, which goes up the hill at Buda; and the light railways connecting the city with the outlying districts. All these systems were inspected by the members of the congress, and the general opinion was that the Pesth and Buda trams are model lines in point of construction, working, and of cheap fares. The congress, which closed on Saturday, passed a resolution declaring that electric motive power for street railways, where a continuous current is used, had proved well worthy of recommendation, but that its applicability in the case of either new lines or old must for the present largely depend on the facilities offered by municipal or State authorities, as the financial results of street electric railways had not always been satisfactory.

Coast Light Communication.—In the House of Commons on Saturday, Sir M. Hicks-Beach asked the Secretary to the Treasury a question upon the supplementary estimate circulated that morning. On the Board of Trade vote on the previous night the question of telegraphic communication with lighthouses and lightships was discussed, and it was understood that a supplementary estimate would be taken for that purpose. The supplementary estimate was for £10,000, which, it appeared, was proposed to be added to the grant towards the Mercantile Marine Fund. Of course, that might be only a matter of form, but he hoped it was not to be taken as an indication that the Government considered the cost of the telegraphic communication ought in any case to be a charge upon the Mercantile Marine Fund. That was not his intention, and he hoped it would not be done, except, of course, where the communication was desired for Board of Trade purposes. Sir J. Hibbert said the supplementary estimate was put in the form in which it now appeared for convenience of discussion. The £10,000 would be kept entirely separate from the Mercantile Marine Fund. Sir M. Hicks-Beach said it had really nothing whatever to do with that fund. Mr. Mundella admitted that that was so. The fund would not bear one farthing of the expense of the telegraphic communication. The Board of Trade intended to execute the work by degrees, and the Treasury would supply the money, for which the Board would account.

Lighting of the City.—The electrical illumination of the City will soon be in full operation. The public arc lighting of the main thoroughfares is finished, and there only remain a few street lamps for which positions have not yet been assigned. The current is supplied from the central station of the City of London Electric Light Company, at Bankside. The buildings here will on completion in the near future form one of the largest and best-equipped stations in existence. In the early part of the summer the length of ways laid by the company was 427 miles; cables drawn in, high tension 60 miles, and low tension 35 miles; and by the end of the year it is hoped the citizens will be supplied with 130,000 8 c.p. lamps. By using two circuits in a street the risk of a thoroughfare being thrown into sudden darkness by the extinction of the lamps through an accidental failure of current is obviated, as the failure of lamps on one side would not affect those on the other. The members of the Commission of Sewers recently decided to press for a reduction in the charge made by telephone companies—namely, from £20 to £8. This resolution was in due course transmitted to the directors of the City of London Electric Lighting Company, who forwarded it on to the telephone company with the request that the application should be considered. It is believed that from 80,000 to 100,000 8-c.p. lamps will soon be in working order, the current being brought into the City at a pressure of 2,200 volts to the transformer stations. These transformer stations are placed in areas (into which, for the purposes of lighting, the City is divided), and the current is delivered from these stations at a pressure of about 100 volts. The City of London Electric Lighting Company has experienced great difficulty in securing sites for these stations, which number 22. At the present time there are over 50,000 lamps connected up, and the end of the year will see the completion of the network of supply. Between £600,000 and £700,000 has been spent by the company in the work already accomplished, upon which some 500 men are now engaged, and as many as 1,000 were employed in the early part of the operations whilst the conduits were being laid in the main thoroughfares.

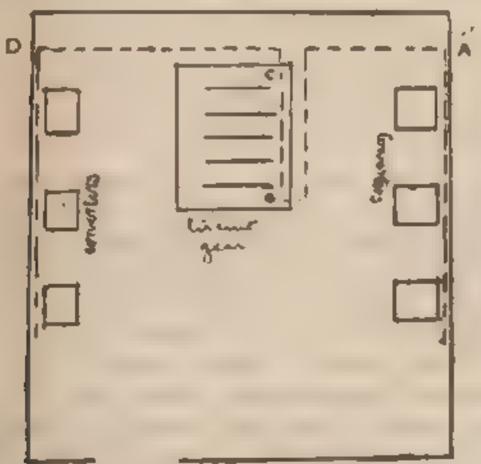
The Government and Telephony.—It is satisfactory to note that the telephone question is to receive proper attention, and that the agreement between the Government and the National Telephone Company is to be placed on the table of the House of Commons before it is r[illegible]

Mr. A. Morley on the 8th inst., in reply to questions put by Sir J. Fergusson, Mr. Hozier, Mr. Stuart, and Mr. Saunders, said that there appeared to be some doubt as to what was intended by the report of the Committee on the Telegraph Bill of 1892. He was informed that some members of the committee understood by the words used that the agreement should be laid on the table before final ratification, while the right hon. gentleman the late Postmaster-General and the right hon gentleman the late Chancellor of the Exchequer, both of whom served on the committee, and the latter of whom was its chairman, understood and intended the words which were used to mean that Parliament should be informed of the terms of the agreement after it was concluded. His right hon. friend was aware that the proposed agreement was intended to carry out the policy for which he became responsible, and, indeed, would be the document embodying in legal form the heads of agreement which he settled with the company, and which were signed by him on behalf of the late Government before he left office. Under these circumstances, and as he (the speaker) understood, he suggested that the document should be laid on the table of the House before its final conclusion, and considering the difference of opinion which appeared to exist as to what was intended by the report of the committee, he had decided to take the course suggested, and to lay the proposed agreement on the table before it is signed. The draft of the agreement was now under the consideration of the company. He was advised that it was in strict accordance with the heads of agreement, which were signed by his predecessor, and with the report of the select committee, as well as with the Treasury minute which was laid before Parliament. It in no way limited or affected the discretion of the Postmaster-General to grant licenses for telephone exchange business. It did not extend the term of the license of the National Company. It restricted the operations of the company to specified areas, and withdrew from them the right to establish and work trunk wires between those areas. But it conferred on the company the right to exercise the powers which were conferred on the Postmaster-General himself by the Telegraph Acts of 1863 and 1878, and by the provisions in the Telegraph Act, 1892, relating to provisional orders. But this right was subjected in every case to the veto of the local authorities specified in Section 5 of the Telegraph Act of last session. Sir J. Fergusson asked whether power was given to take up streets without the consent of the local authorities. Mr. A. Morley replied in the negative, and said that it was subject to the veto of the local authorities. On Monday, Sir R. Temple asked the Postmaster-General whether there would be any conditions in the proposed agreement between the National Telephone Company and the Post Office which would in any way limit the power of corporations, county councils, and other local authorities to impose any conditions they may think fit as to charges or otherwise on the National Telephone Company as a condition of permitting them to continue their telephone service, or obtaining further local privileges and powers—underground or otherwise. Mr. A. Morley answered in the negative. The matter was regulated by statute, and he would refer the hon. baronet to Section 5 of the Telegraph Act of last year. He promised to lay the agreement on the table before it was ratified.

Mechanical and Electrical Oscillations.—Mr. N. Tesla lectured on this subject at the recent Electrical Congress in Chicago. In relating his introductory work in oscillations, according to the *Electrical World*, he spoke of the experiments made with a plate in a magnetic field, inserting the plate slowly and withdrawing it rapidly, and *vice versâ*, and actually producing rotation of the plate by oscillating the field, etc. Owing to the difficulties attending the use of high-frequency dynamos with a rotating armature of great speed, he desired to get a machine which would imitate the process of the Leyden jar by mechanical means and produce an oscillation of any frequency desired. The plan was to produce very rapid mechanical oscillation of small amplitude and vibrate either the armature wires in the magnetic field or the iron in the field and armature coils. The oscillator constructed for this purpose consists essentially of a very short cylinder with piston and valves, and a spring to resist the motion of the piston-rod. The piston is operated by compressed air at 60lb. per square inch. The valves are adjusted to produce a powerful cushioning effect in the cylinder at each stroke; or, as in the latest form of machine, to regulate the exhaust. The compression reaches as much as 16 tons, and the weight of piston and plunger is about 20lb. The ports on the largest of his oscillators were about the same size as in a 15 h.p. steam-engine. The period of vibration depends upon the resonance of the chamber and spring, and thus is not affected by a change in the air pressure. A simple analogy is the case of a musical string or bell—their tone does not depend upon the force with which they are struck; also with a pendulum the period is independent of the force applied in starting it. This enables oscillations of absolutely constant frequency to be obtained, thus producing currents of perfect vibration unaffected by air pressure, E.M.F., or any other condition, which discovery Mr. Tesla believes to be of the greatest importance. An interesting experiment was performed by attaching to one of these oscillating pistons a circular magnet with the poles on the top ½in. apart; a copper disc placed between the poles was rotated, due to the oscillating field and the retardation of the lines of force. Three different types of machines were shown for producing high-frequency alternating currents. In the first, which had a horizontal shaft, the armature consisted of a cylindrical iron core around which the wires were wound perpendicular to the shaft, and the field was a simple bipolar electromagnet; the oscillator was at one end of the shaft, which, with the core, vibrated longitudinally, and therefore the armature wires were oscillated across the field with an amplitude of about a quarter of an inch. In the second, also with horizontal shaft, there were two armatures and two fields, with the oscillator in the middle; the armatures each consisted of two flat, rectangular coils without iron, and were oscillated between the poles, which were in this case very close together. In the third, the field and generating coils were wound on flat screws of equal size and placed over each other, and the joint iron core of both armature and magnets was oscillated in their centre, the shaft being vertical. The outer or field coils were supplied with a constant current. The inner or generating coils were connected in series with the condenser. Mr. Tesla stated that he hopes to perfect these very soon and would use them as generators for his high-frequency currents, but the machines at present, though imperfect, were both light and fairly efficient for the power developed. The only experiment shown with this latest form of "high-frequency dynamo" was the operation of a small synchronising motor with closed-coil armature, the success of which was greeted by a burst of applause. Mr. Tesla, in closing, alluded to the great possibilities that were in store for these high-frequency generators. Currents of any period whatever could be supplied by the central stations, and synchronising motors operated thereby. The period would be so absolutely constant that clocks could be run with perfect regularity by means of it.

THE ACCIDENT AT THE BLACKFRIARS SUB-STATION, L. E. S. CO.

In the usual inflated style there appeared in Wednesday's papers an item of news headed "Shocking Accident at Blackfriars," with details to the effect that fatal injuries had resulted to one of the men engaged in the electric light station there, another being very seriously burnt and otherwise hurt. There is no need to minimise the facts; indeed, they ought to be noted very exactly, in order to show the importance of care in such work as this on the part of the men. If a plumber breaks into a gas-main, by the light of a tallow candle, the only satisfaction he usually gets for being blown up is to be called a fool for his wanton carelessness. The position in the present instance of the man in charge at the Blackfriars station was very similar, although, sad to relate, the poor fellow has lost his life under melancholy circumstances. As our readers will remember, the London Electric Supply Company have erected several sub-stations at different points of their circuits, where converters are provided for reducing the current pressure from 10,000 volts, at which it leaves Deptford, to 2,400 volts, the latter being again reduced to 100 volts by the converters on consumers' premises.



The annexed plan—for which we are indebted to Mr. P. W. D'Alton, the company's engineer—will show clearly the arrangement of converters and switch gear at Blackfriars, where one of these sub-stations is placed. The 10,000 volt mains are not shown, but those carrying the secondary current at 2,400 volts (in connection with which the accident happened) are represented by dotted lines — — —, and — · — · —, according as they are below or above ground. At A, B, C, and D are four plug switches, by means of which the load may be transferred from one row of converters to the other, or both may be kept in circuit if desired.

It appears that on Tuesday night, after changing over from one set to the other—that is, from the set on the right hand of the plan to that on the left—the main switch in the primary circuit of the unused converters being of course thrown out, the unfortunate man who now lies dead at Guy's Hospital, and who was in charge of the station, omitted to take out the plugs at B and A, as he should have done in accordance with the rules of the company. The consequence was, of course, that the secondaries of the right-hand side converters were in circuit with those on the opposite side which were carrying the load, and the assistant who had been detailed to clean and dust the converters and fuses no sooner happened to touch the frame of a converter with one hand whilst dusting with the other, than he at once received the full force of a 2,400 volt shock.

On seeing him in this condition the deceased man immediately rushed forward and tried to pull him away, but himself received a severe shock, and was thrown back violently upon his head, and it seems at present as though his death were due more to the effects of the fall than to the electric shock, inasmuch as he could hardly have taken the full force of the current through the assistant's body. Both men, it should be said, were wearing shoes with very thick indiarubber soles, and were, therefore, as much as possible insulated from the ground. The assistant is now in the hospital suffering from severe burns and shock to the system, but it is hoped will make a good recovery.

This unfortunate accident was clearly due to the fault of the deceased man himself, in not carrying out the rules laid down for his guidance; had the plug switches been removed in the usual way—a procedure gone through time and again by the man himself—no danger whatever would have been incurred. He had been in the employ of the company for six years, and was a man of fine physique. The assistant is a young man, 20 years old, only engaged a year or 15 months ago. Although, of course, there will be statements made as to the company being at fault, it seems quite evident that in this case no possible blame can be attached to them; the accident resembles very much those which sometimes occur on our railways, when an engine-driver forgets his position and runs past a danger signal to his own destruction. It is, however, none the less regrettable from every point of view.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

DISTRIBUTION OF ELECTRIC POWER.

(Continued from page 223.)

Low-Pressure System.

In order to equalise the pressure over a network of distributing mains as much as possible, and to enable a farther distance to be supplied without any increase of the fall of pressure in these mains, the method of trunk mains was adopted, these trunk mains being used solely and simply for conveying the current to several determined centres in the network. No branch wires are tapped off these trunk mains, and no lamps are run off them, so that they serve as "feeders," and are known by that name. It is evident that the more "feeders" there are, the more will the pressure be equalised over the system, because there will be more central points, at all of which the pressure will be maintained constant and the same. At the end of each pair of "feeders"—that is, at each "feeding centre"—a thin pair of "pilot" wires are taken back to the dynamos, so as to indicate what the pressure is at the centre. As a practical illustration, we may take that 112 volts is the pressure that must be maintained constant at the feeding centres, and at full load; this may mean, say, 118 volts at the terminals of the dynamos: for the nearer centres a little less, for the farther centres a little more, when all the centres have different distances. As the current flowing in each feeder increases or decreases, so a greater or less pressure will be required at the dynamo terminals in order to always maintain the 112 volts pressure at the feeding centre. Taking as six volts the total fall of pressure along the feeder at full load, there will only be required 115 volts at the dynamo when the load in that feeder is reduced to one half. By adding a number of "feeders" to the simple parallel system, the radius distance of the supply mains can be increased to double, treble, or even more. The greater the length of feeders supplied, and the more feeding centres there are in the network of mains, the more equalised will be the pressure.

No low pressure systems of distribution are carried out without employing feeders in a judicious manner, and as they are solely for the purpose of giving better regulation to the supply mains, the money sunk in them becomes an additional expense. It is found that in a well-designed distribution system the money spent on feeders should be between 30 per cent. and 50 per cent. of the money spent on the distributing mains, according to the nature of the area to be supplied.

Fig. 26 gives an idea of the way feeders are used. Where A, B, C, D, E, F are the six feeding centres, and *f* the "feeders," the distributing mains denoted ... out from each centre, and those near

are joined together, and so make a circuit round the source; only the positive wires are shown, to make the diagram clearer. Of course the position of the centres and their number and proximity to each other are determined by the nature and extent of the district, and the diagram given is merely to show how they are employed, it being almost impossible to get a district where the distributing mains and feeding centres can be arranged perfectly symmetrically, as in the case of Fig 26. If the current that is flowing is reduced to one-half of its value, whilst at the same time the pressure is doubled, we still have the same electrical power; and generally the current can be reduced by as many times as the pressure is increased without altering the value of the product which represents the power generated. We showed that a main cable of 1in diameter and 500 yards long had a resistance of about ·016 of an ohm, and that with a current of 500 amperes flowing through, the fall of pressure throughout its length was eight volts, so that if the pressure at the generating end of the cable be 100 volts the fall is then 8 per cent. But suppose we work our lamps with a current of only half that value, 250 amperes, and at a pressure of 200 volts, the power is the same; but instead of our lamps being fixed in simple parallel they must now be arranged in parallel rows of two in series—that is, two lamps in series must now be placed across the positive and negative mains so as to absorb the 200 volts—because the lamps are only made for 100 volts pressure. The same current passes through the

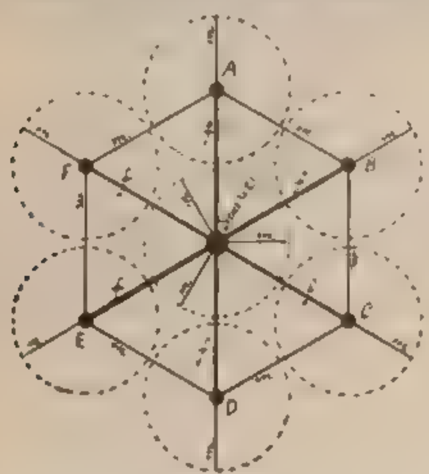


FIG. 26.

two lamps that are in series, so that the total current used is obtained by multiplying this current by one-half of the number of lamps in use. In the simple parallel arrangement, the total current is obtained by multiplying the current through the one lamp by the number of lamps there are. From this, we see that for the same number of lamps we only require one half the current when the pressure is doubled.

If our current is now 250 amperes, the sectional area of the cable can be reduced correspondingly, and this will give us the same current density, the resistance is doubled, and so we have the same fall of pressure—namely, eight volts; but the working pressure is now 200 volts, and so we obtain a fall of only 4 per cent. instead of 8 per cent., as with 100 volts.

Reckoning in the negative cable as well, there is a total fall of pressure of 16 volts in both cases, but on the 100 volt circuit each lamp received only $100-16=84$ volts, whereas, on the 200-volt circuit each lamp receives $(200-16)\div 2=92$ volts. Therefore, keeping the percentage of loss constant—that is, the loss for each 100-volt lamp—doubling the pressure will allow the current to be carried double the distance, or

Distance is proportional to Pressure.

The above fact furnishes us at once with a means for extending the distributing area of a system. The three-wire system of distribution enables us to use 200 volts, the third wire being called the "neutral wire," because when there is a balance of load of each side of it—that is, when there are as many lamps burning between the positive and neutral wire as between the negative and neutral wire—there is no current flowing in it. Fig. 27 shows the connections of the three wires.

The dynamo is wound for a constant pressure of 200 volts, and the pressure can be regulated by a rheostat in the shunt coils, for compensation for fall in the circuit. The third wire, signified by N, is placed between the positive and negative wires, but does not return to the dynamo. Service mains for 100 volts can be taken off either + and N or N and −, because the + is at 200 volts pressure and − at 0. Of course the circuit can only be completed when there are lamps on *both* pairs of mains, as the lamps of one pair are in series with the lamps of the other pair.

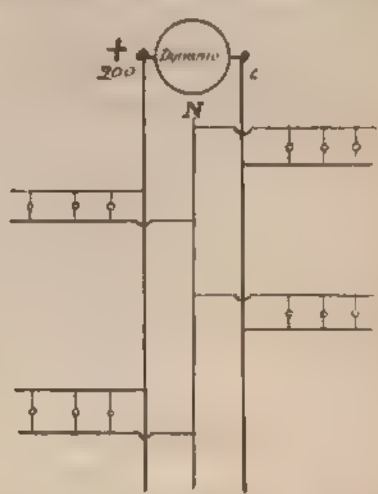


FIG. 27.

Fig. 26 shows four tappings of service mains, two being taken from + and N, and two from N and −. By having this neutral wire, N, should one lamp go out the others will not be thrown out of circuit, whereas if the lamps were fixed two in series straight across + and −, then one of the pair going out would make its fellow go out.

Since there is a current flowing through the neutral wire only when there is an inequality of load, it is usual in practice to make its sectional area not much more than one half what either of the other two may be; in some cases it is made only one third. There is, therefore, a great saving of copper in the three-wire system as compared with

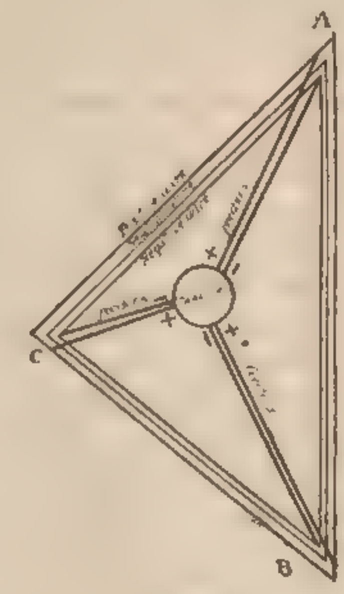


FIG. 28.

the two-wire system. Allowing a two-wire system to have cables of 1in. diameter, the total sectional area of copper employed is 1·5708 square inches.

With the three-wire system, we have first the sectional area of the two mains, + and −, reduced to one-half, because one-half of the current is used; but at 200 volts, the percentage of fall of pressure for equal distances is only one-half, so that to bring it up to the same as the two-wire system, we can double the current density, and this can be

done by reducing the sectional area again by one-half, so that the two mains have now a total area of one-quarter of those on the 100-volt circuit, or ·3927 square inches, each main being ·5in. diameter. The third, or neutral, wire having one half the area of either main, will have ·098 square inch; so the three wires will have a total of ·3927 + ·098 = ·4907 square inch, or very nearly half an inch. Hence we have

$$\left.\begin{array}{l}\text{two-wire system} = 1{\cdot}5 \text{ square inch}\\ \text{three wire system} = {\cdot}5 \text{ square inch}\end{array}\right\} \text{approximately,}$$

giving the latter a saving of 66 per cent. in weight; and the area of the district supplied will be increased four times, because doubling the radius quadruples the area.

It must be remembered that this is under the conditions of same distance and same percentage of fall of pressure. By allowing the three-wire system to go to twice the radius distance, keeping the percentage of fall constant, there would then be a saving of 33 per cent. in the weight of copper used.

Fig. 28 shows how "feeders" are supplied to a three-wire system, there being three feeding centres, A, B, and C. The outer cable is positive, the inner one negative, whilst the third, or neutral, wire is in the middle. Both positive and negative feeders are shown, the positive feeders being connected to the outer wire and the negative feeders to the inner wire.

(To be continued.)

A NEW INCANDESCENT ARC LIGHT.*

BY L. B. MARKS, M.E.

(Concluded from page 227.)

Comparing these measurements with those of radiant efficiency, it appears that the ratio

$$\left\{\frac{\text{hemispherical candle-power, "incandescent arc"}}{\text{hemispherical candle power, ordinary arc}}\right\}$$

is considerably smaller than the ratio

$$\left\{\frac{\text{hemispherical efficiency, "incandescent arc"}}{\text{hemispherical efficiency, ordinary arc}}\right\}.$$

The explanation of this difference undoubtedly lies in the quality of luminosity of the light emitted by the incandescent arc. Nichols has pointed out that the relative efficiency, as determined by the ratio $\left\{\frac{\text{luminous radiation}}{\text{total radiation}}\right\}$ "does not coincide with that obtained from the ratio of watts to candle-power, for the reason that the various rays which make up the visible spectrum do not enter into the production of candle-power in proportion to their energy." Luminosity is a potent factor in determining the real efficiency of any source of illumination. Lack of time has prevented the investigation of this important phenomenon, but at its maximum efficiency the light from this form of incandescent arc, though not so intense, unmistakably appears brighter than that of an ordinary arc of equal candle-power as interpreted by the photometer.

Life Tests.—Oxygen being practically excluded from the arc-enclosing chamber, prolongation in the life of the electrodes is an implied concomitant. In the ordinary arc "while the positive carbon loses by volatilisation from its tip or crater, and by combustion from its sides, the negative gains no deposit, but wastes at a less rate than the other, and by combustion only." Hence, if the exclusion of oxygen were complete, we might expect an indestructible negative. This condition, however, has not been fulfilled in any of the tests made thus far, but the results fully substantiate the theory. Absence of combustion on the one hand, and the tension of the enclosed gases on the other, combine to greatly reduce the amount of disintegration of the positive electrode.

Tests made showed 1·69in. per hour as the average consumption of carbon in the commercial 350-watt lamp, run at 5½ amperes and 50 volts. We note that although 525 watts, or one and one half times the energy, have been expended in the case of the lamp under consideration, yet the life per inch of carbon consumed is more than twenty times that of the other. Indeed, the figures show that the life of the negative was nearly one hundred times as great as that obtained in commercial practice to-day.

The preservation of the negative is a very interesting feature of this type of lamp. There is a marked tendency towards deposition of the products of volatilisation of the upper electrode on tip of the lower, the carbon deposited, if not ruptured by the action of the lamp, forming an internal part of the negative. In one case where, the arc having been sprung, the electrodes did not come in contact during the entire run, this "building up" process was beautifully exhibited, the negative electrode gaining practically all that the positive lost. The current in this instance was 10½ amperes and the P.D. 50 volts. The duration of the run was 11 hours.

Observation of the Arc.—Relation of P.D. to Length of Arc and Quality of Carbon.—The effect of the enclosed gases on the form and character of the arc presents a large field for investigation. On account of lack of sufficient data, no attempt will now be made to state much of a definite nature regarding this subject; but it is hoped that the matter will be given due attention in the near future. The difference in potential between the electrodes being equal, the incandescent arc is longer for a given current than the ordinary arc; under some conditions it has been found to be almost twice as long. If we accept the conclusion of S. P. Thompson, that "the arc is independent of the nature of the surrounding gas," we must then look to the effects of the tension or pressure of the heated gases upon the arc to explain this difference in length. It has been found that there is a constant increase of P.D. with pressure above atmosphere, for a given current and length of arc. But, in spite of this fact, the decrease in resistance of the arc under the conditions named appears to allow of a greater length for the same P.D.

Flaming and Hissing.—In the ordinary arc the carbon vapour carried off from the positive is consumed by the oxygen of the air before it can deposit on the negative. Hence the ever-present "zone of flame," as distinguished from the arc-flux proper, is really a zone of combustion. In the incandescent arc, however, there is naturally no zone of flame, consequently the phenomenon of flaming common to the ordinary arc does not occur. The arc tends to centre itself, being probably aided in so doing by the pressure of the surrounding gases; moreover, the slow consumption of the electrodes lessens the tendency to wander. With cored carbons there is a perceptible crater, but with solid pencils the tips become more or less flattened.

The quality of the carbon has an important bearing on the P.D. between the electrodes. Generally speaking, it has been observed that with soft fine-grained carbons the P.D. is considerably lower for a given current than with harder or coarse-grained pencils. The tendency to hiss, however, is not so marked when the electrodes are consumed in the gas-chamber as in the open air; in the former case the disintegration is so slow that the "electrolytic" vapourisation, as it has been called, does not appear to explode the particles. It is interesting to note here that these results confirm a theory of hissing advanced by Prof. Thompson a few years ago.

The Alternating-Current "Incandescent Arc."—No measurements were made using the alternating current; but the appurtenance was applied to the alternating-current arc lamp to determine the effect on the noise of the arc. The hum was in a large measure reduced, but whether the reduction was due mainly to the mere fact of the arc being enclosed in an airtight compartment or not, is questionable. But as the hum became much slighter after the lamp had been in operation several minutes, the action of the heated gases being then manifest, it is plausible that the diminution in the noise was not due entirely to the shielding property of the glass envelope.

While it has been proven that "the humming of the alternating-current arc is due to the rapid periodic extinction and re-establishment of the discharge," the singing tone may be greatly modified, if not entirely overcome, by the substitution of any incandescent arc of the Reynier type. A few years ago the writer had occasion to test an

* Abstract of a paper read at the International Electrical Congress, Chicago.

alternating-current arc lamp trimmed with carbons which had been provided with a core of pulverised mica and carbon. The springing of the arc was accompanied by the usual hum, but as soon as the mica fused the noise ceased. The conditions were similar to those of an incandescent arc, the plastic mica-carbon core constituting a high resistance medium between the plus and minus electrodes. There was really no true arc. The amount of light was naturally greatly reduced. In the case of the incandescent arc first alluded to, there seems to be an approach to these conditions, the arc stream acted upon by the gases enclosed in the chamber appearing to have a greater density, if we may call it that, than under normal circumstances. The amount of light in this experiment was, however, apparently as great as in the direct-current tests.

Application to the Arts.—Unquestionably this form of incandescent arc must have a wide application to the arts. As a substitute for the ordinary arc light, where greater steadiness or longer life is required, its superiority will be manifest. And its utilisation, where at present the incandescent lamp is the only satisfactory source of illumination, also presents a large field. The effective distribution of luminous energy and the colour of the light make it for many purposes a desirable mean between the incandescent and the arc. As a standard source of illumination for arc light comparison and measurements it may be of much scientific as well as utilitarian importance. The investigations have been carried out under the direction of Mr. Louis E. Howard, and many of the facts herein stated are due to him. The writer is also indebted to Dr. Edw. L. Nichols, Franklin L. Pope, and Robt. H. Read for valuable suggestions; to Mr. C. Ransom for life tests; and to Messrs. Wm. C. Hubbard and E. S. Ferry for assistance in the efficiency and candle-power measurements.

MEANS OF DIMINISHING SPARKING IN CONTINUOUS-CURRENT DYNAMOS.*

BY W. C. RECHNIEWSKI.

(*Concluded from page 176.*)

In the preceding article we have spoken of the influence of the form of the dynamo carcase, of the saturation, and of the various systems of winding, on the sparking at the brushes. Beyond these general conditions it has been proposed and attempted to use various special means to diminish sparking. We shall mention a few of these.

For every good continuous-current machine there is, as is known, for each current a position of the brushes which gives no sparking. As soon as the brush is shifted forward or backward of this position there is sparking, for the reason that there is a sudden change of current in the short-circuited coils when leaving the brushes.

In order that there shall be no sparking, the field in which the short-circuited coil moves must be sufficiently strong to reverse the current in this section during the time it is in short circuit, so that when the brush leaves the short-circuited segment, and the circuit is broken, there is no sudden change of current. The stronger is the current in the dynamo, the stronger must the field be to produce commutation without sparking. We see, therefore, as Mr. Swinburne has pointed out, that even if there were no armature reaction at all, the brushes would still have to be set forward in the direction of the rotation of the armature so as to prevent sparking when the current increases.

The reaction of the armature can only render the phenomenon more intense, as it tends to weaken or even reverse the field in which is the section passing under the brushes.

We can, therefore, divide the means of diminishing sparking into two—magnetic means and electric means. The first act on the field in which the section under the brushes is moving, the second act directly upon the sparking.

Magnetic Means.—It will be noticed at once that a series-wound dynamo has a much more stable position of brushes, as the magnetic field increases in these machines with the current, and a fixed non-sparking position of brushes can be found for large variations of current. Generally, however, the saturation of that magnetic circuit which causes the increase of field is not proportional to the current, and the reaction of the armature, especially for large machines, renders a shifting of brushes necessary when the load approaches its maximum.

The reaction of the armature being objectionable, a whole series of processes have been proposed in order to diminish this reaction as much as possible.

The first in date is the compound winding of dynamos, which Prof. Ryan has perfected by making the wires carrying the principal current, C, pass through holes in the polar surface near the armature, Fig. 6, so as to form along the polar surfaces a sheet of current parallel to that of the armature and neutralising it.

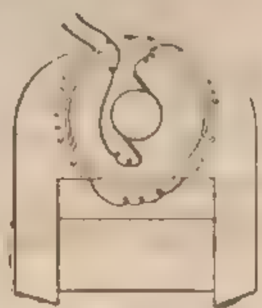


Fig. 6.

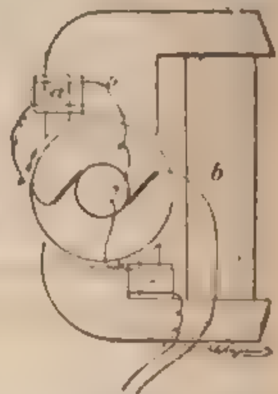


Fig. 7.

Another proposal, which has much analogy with the preceding one, consists in furnishing the horn in front of each pole-piece with an appendix, *a a*, around which is sent the total current of the machine, while the main electromagnet, *b*, is only excited in shunt, Fig. 7.

A large number of modifications of this process have also been proposed by taking, for instance, special electromagnets completely separated from the principal field magnet to reinforce the field of the short-circuited coil.

Mr. Swinburne has proposed to make the armature in two parts, Fig. 8—a first part, the most important, with magnetic fields, N and S, for the production of electric energy, and a second, whose fields, N′ S′, are solely for the purpose of suppressing sparking. In this arrangement each turn of the armature passes into the two parts, I and II, of the armature before coming to the commutator.

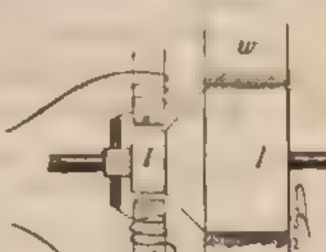


Fig. 8.

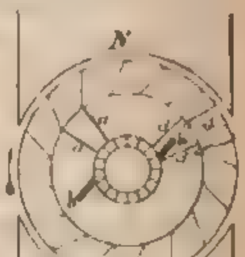


Fig. 9.

All of these arrangements act well, and in many cases render good service. Unfortunately they complicate the construction, and, in general, render its manufacture more costly.

To thoroughly understand the interest which attaches to these attempts, it is necessary to remember that if we could find a means of entirely suppressing sparking at the brushes, not only one of the greatest disadvantages of the dynamo would disappear, but the construction itself of all dynamos would probably be greatly modified; we could, indeed, use the current in the armature to produce the magnetic flux necessary for the field, and the winding on the field magnets would be no longer needed.

Further, there would be no waste flux; in fact, the flux

* From *L'Electricien*.

being generated by the armature itself would entirely pass through the coils of this armature, which would allow us to reduce the section of the fields, whose part, as we see, would be materially reduced.

This is what Mr. Sayers, of Glasgow, has recently attempted by a remarkable winding which we will now describe, Fig. 9. Let us consider a Gramme ring. If the brushes are shifted backwards, as shown in the figure, the current circulating in the armature will tend, as is known, to reinforce the field, instead of diminishing it, as in the ordinary dynamos, where we are obliged to shift the brushes forward.

Such a machine would self-excite without winding if the magnetic resistance of its current were small enough. What prevents this being done in the ordinary machines is the sparking. To suppress this, Mr. Sayers employs the following process: instead of leading directly to the commutator the junctions of contiguous sections of the armature by conductors, *a a*, Fig. 9, as is usually done, Mr. Sayers gives to these conductors one or two turns on the armature at *d d*, Fig. 9. Thus, when a coil is short-circuited by the brushes, it is acted upon by three E.M.F.s as follows:

1. That generated in the coil, *s*; we call this *e*.
2. That generated in the added coil, *d*; call this e'.
3. That generated in the added coil, d'; call this e''.

The sum of the forces acting on the section is therefore $e'' + e' - e$.

By properly proportioning the dynamo (to enter into details would lead us too far) it may be arranged so that the sum of these forces is such that there is no sparking at the brushes.

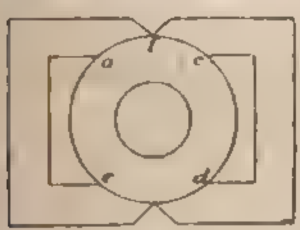


FIG. 10.

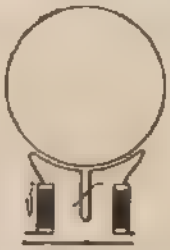


FIG. 11.

Mr. Sayers has already built several machines of this kind with no winding on the fields, which have been working regularly for several months. It will be noticed that in this winding the quantity of wire on the armature must be increased, as each junction with the commutator is wound round the armature; but this arrangement does not sensibly increase the resistance, as the current does not pass through these junction coils except at the time their segments are passing under the brushes.

If we wish to construct a compound machine on this system, the shunt winding is put on the fields and the compounding is done with the winding of the armature itself.

In all dynamos the reaction of the armature shows itself in two different fashions:

1. The ampere-turns in the free space between the pole-pieces between *c* and *d*, *a* and *e*, Fig. 10, which act directly to increase or decrease the field.

2. The ampere-turns beneath the pole-pieces, *a* and *c*, *e* and *d*, Fig. 10, which tend to twist the field.

We have seen how Mr. Sayers has been able to use the first to increase his magnetic field, while in the ordinary dynamos, where we are obliged to advance the brushes, the ampere-turns are opposed to the production of the field and weaken it.

To diminish the twisting of the field caused by the layer of current which is beneath the pole-pieces, the following different means have been proposed. The Thomson-Houston Company divide by a slot, *f*, the mass of the fields to diminish the transverse magnetisation caused by the armature, Fig. 11. Others, again, amongst them the author, have proposed to divide the poles of the Manchester type by a slot, *f*, Fig. 10, separating the fields into two parts. Mr. Sayers has adopted this arrangement for his dynamos. Prof. S. P. Thompson has proposed to construct laminated field magnets, insulated magnetically between each other, Fig. 12.

We may point out here, also, that a cast-iron field magnet magnetically saturated acts exactly in the same way—the transverse magnetisation cannot be developed.

Electric Means.—I term electric means those which, without modifying the form of the machine, act on the sparking itself. As a first example may be mentioned the air-fan of Elihu Thomson. As is known, the commutator of his dynamo is composed of three segments insulated from each other by a somewhat wide air space, the violent sparking which is produced is simply blown out by a strong current of air (an arc being easily put out by blowing). This mode of working is not perfect, and can only be used for small currents.

The following arrangement has been tried by the author with entire success (see Fig. 13). The commutator of an ordinary continuous-current dynamo was constructed so as to have very thick insulation (shown by the hatched portions on the figure), and the brushes composed of three parts:

1. The normal brush, *b*.
2. Two small auxiliary brushes, b', b'', not communicating with the principal brush, except by the intermediary of two resistances, R and R'.

It is easily seen that when the principal brush, *b*, leaves a segment of the commutator the spark is not produced, because the current can still pass by the brush b', but weakened by the resistance R, which it must first pass through. In the same way when the brush b' leaves the segment, a spark still tends to be produced, though much smaller than before; but this is suppressed, as the current can still pass by the brush b''. The resistance R' may be

FIG. 12.

FIG. 13.

made high enough so to diminish the current that there is no sparking at all when the last brush, b'', leaves the commutator segment.

It is evident that several brushes can be used, but three will be found sufficient. In the carbon brush we find, moreover, a rudimentary application of this process. The diminution of sparking which is noticed with the use of carbon brushes results in great part from their high resistance, which causes the rupture of the short circuit between two commutator segments to take place, not suddenly, but gradually.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE I.

THE CONDITIONS IN WHICH DISTRIBUTION OF ENERGY IS REQUIRED—SOURCES OF ENERGY—THE CONDITIONS OF ECONOMY AND WASTE IN PRODUCING STEAM POWER.

In carrying out the duty imposed upon them by the terms of the bequest of the late Mr. Thomas Howard, the council of the Society of Arts did the author the honour of inviting him to give a course of lectures on "The Development of Power at Central Stations," and its distribution either as motive power for use in factories or workshops, or as energy applied to other purposes. Energy is in these lectures to be considered as a commodity which can be produced, distributed, and sold. The special problem is to examine the advantages of producing the energy in a wholesale way; the means of conveying it to a distance and distributing it to various working centres; and the relative advantages and disadvantages of such a system compared with the method of producing the energy in the localities where it is used

As various sources of energy and methods of producing and distributing it are available, the enquiry is a wide one. In the time at my disposal it will only be possible to pass rapidly in review the matters of most importance, leaving gaps which may

* Howard Lectures delivered before the Society of

be filled at some future time. That the author has more knowledge of some of the older and more mechanical methods of power distribution than of the newer methods of electrical distribution is no doubt a disadvantage. But electrical methods have already been very fully discussed. On the other hand, there may be some advantage in approaching the subject with the bias of an engineer rather than of an electrician. Granting, what no doubt is true, that electrical transmission will play an important part in the development of systems of power distribution, there is perhaps, a popular tendency at the moment to regard too exclusively this single method and to overlook other means of power distribution which have been usefully applied, and will still be used in the future.

Those who see the electric lamp are perhaps a little apt to attribute to electricity too predominant a share in the production of the light. They forget the engines and boilers, which are as necessary as the dynamo in obtaining the result. Similarly, the striking success achieved in transmitting power electrically to great distances has tended to obscure the fact that other methods of power transmission are more convenient and less costly in particular cases.

Two points should be clearly kept in mind. First, that as to the production of energy in an available form, we are just where we were before modern electrical discoveries were made. The most the electrician can do is to provide a new mechanism of distribution. I should have to state the case differently if, by primary batteries employing new materials for chemical action, or by thermo-electric batteries in which heat is directly transformed into electricity, the methods of producing available energy were changed. Such things are theoretically possible. Practically they are not yet available. At present the energy to be distributed must be developed by a steam engine or waterwheel, and the dynamo cable and electric motor merely replace the shafting, gearing, and belting, or other mechanism of transmission, performing the same functions more cheaply and effectively in certain cases it is true.

The second point is that every method of transmission will be found to have some characteristic advantages fitting it specially for particular cases. It may be conceded to the electrician that the special advantages of electrical transmission are very strikingly apparent where power must be conveyed to very great distances. But such cases are likely to be rare. The remarkable mechanical and scientific success of the Frankfort-Lauffen experiment, in which 300 h.p. was conveyed 108 miles with a loss of only 25 per cent., has a little misled merely popular observers. The fact must be borne in mind that the cost of the power when it reached Frankfort was five times as great as that of an equal amount of power produced directly in Frankfort by a steam engine. Transmissions to much smaller distances are the only ones likely to be often required, and for moderate distances there is choice of various methods of transmission besides the electrical method.

Reasons for Distributing Power from Central Stations.—The advantages of generating power at central stations may be enumerated thus:

1. In generating power by steam there is economy of cost of machinery, of fuel, and of superintendence due to concentration of the engines and boilers in a single station

2. In the case of water power, very often it is only possible to deal with a natural waterfall by a combination of consumers, or by an association acting in the interest of many consumers for the construction of the costly permanent works required.

3. The locality for generating power may be fixed by one set of conditions, that where it is used by another set of conditions. Often it is a question of adopting a cheaper source of power at a distance, or dearer near at hand. Thus in mining and tunnelling operations, cheap steam power, generated at the ground surface, may be distributed in the workings to replace much more expensive hand labour. That is essentially a case of power distribution from a central station. Mr. Thwaite has recently proposed to erect large gas-motor stations at collieries, and to transmit the power electrically to the nearest manufacturing centres.* Whether that is desirable is a question of finance entirely. The question is whether the economy in producing the energy covers the cost of its transmission to a distant working point.

4. Another reason for central stations arises in this way. For good or for ill, population gathers into huge communities in which there is a complex development of social and industrial life. In such communities there is a constantly increasing need of mechanical power. For transit, for handling goods, for small industries, for lighting, for water supply, and sanitation, new demands for mechanical power arise. At first these are met by the erection of scattered motors. This sporadic production of power is extravagantly wasteful, costly, and inconvenient. There is a chance in such cases that power distributed from a central station may be cheaper even when the cost of distribution is allowed for.

Just as it has become necessary to supersede private systems of water supply by a common supply; just as it has proved convenient to distribute coal gas, and necessary to establish a general system of sewerage, so it will probably be found convenient, and even necessary, to provide in towns of a certain importance some means of obtaining mechanical power in any desired quantity, and at a price proportional to the amount of power used. It is socialism in the field of mechanical engineering.

For the single purpose of working lifts and hoisting machinery, it has already proved remunerative to extend through the streets of London a system of nearly 60 miles in length of hydraulic mains. The extremely rapid extension of the system is worthy of note. In July, 1884, there were only 96 consumers taking power from the London Hydraulic Company's mains; in 1888 there were 720 consumers renting power; in 1892 there were 1,676 consumers renting power: and the use of the system is now extending more rapidly than at any previous period. The quantity of water distributed has increased from 317,000 gallons per week in 1884, to 6,000,000 gallons per week in 1892. In no instance has the use of hydraulic power when once adopted been abandoned in favour of any other system of working hoisting machinery.

* The *Engineer*, December 2, 1892.

There can be no doubt that when (*a*) power can be obtained with little trouble in a form involving no great amount of superintendence in working, and (*b*) the cost is proportional to the amount of power used, then a demand for the power is readily created.

Perhaps a more striking instance of the growth of a demand for power is furnished by the town of Geneva. No casual observer would have selected Geneva, with its population of 50,000, as a likely centre for a great system of power distribution. Yet the works at Geneva, which will be more fully described later, are perhaps the most important example of power distribution hitherto carried out in 1871. Count Turrettini obtained permission from the Municipal Council to place a water pressure engine on the existing low pressure town mains for driving the factory of the society for manufacturing scientific instruments. In the case of this method of obtaining power proving satisfactory, he obtained the right to instal similar motors in other parts of the town. The plan proved so convenient that nine years afterwards, in 1880, there were 111 water motors driven from the low pressure town mains, using 34,000,000 cubic feet of water annually, and paying to the municipality £2,000 a year. The cost of the power was not small. It was charged for at 3d. to 4d. per horse-power hour, which is equivalent to a rate of £36 to £48 per horse power year for motors working continuously for 3,000 hours in the year. Since that time a new high pressure service has been established, the water being pumped by turbines in the Rhone. On the high pressure service the cost of the power is less. It is charged for at about 0·7d. per horse power hour, equivalent to £8 per horse power year of 3,000 working hours. In 1880 the annual income from power water sold on the low pressure system was £2,035, and on the high-pressure system £4,500. At that time the receipts for power water were increasing at the rate of £880 per annum. In 1889 the motive power distributed on the high pressure system amounted to 1,500,000 horse-power hours, there being 79 motors, aggregating 1,279 h.p.

This illustrates sufficiently the growth of the use of motive power distributed in a convenient form. The power used in pumping the ordinary water supply for municipal and domestic purposes is not included. It will be seen later on that the works, taken as a whole, are very large and important.

The location of the windmill on the hill, and the watermill by the stream, indicates how conditions of human labour have been determined by the need of mechanical energy. The earlier cotton mills were all placed where water power was available, although this had the disadvantage of taking them away from the places where skilled workmen were found, and from the markets for manufactured goods. In an interesting pamphlet on "The Rise of the Cotton Trade," by John Kennedy, of Ardwick Hall, written in 1815, it is stated that for some time after Arkwright's first mill was erected at Cromford all the principal mills were built near river falls, no other power than water power having been found practically useful. After the invention of the steam engine, manufacturing industries gathered round the coalfields. "About 1790," says Mr. Kennedy, "Mr. Watts's steam engine began to be understood, and waterfalls became of less value. Instead of carrying the people to the power, it was found preferable to place the power amongst the people." The tendency of the conditions created by the introduction of steam power has been to concentrate the industrial population into large communities, and to confine manufacturing operations to large factories. Economy in the production of power, economy of superintendence, and the costliness of the machinery employed, all favoured the growth of the factory system. Facilities for distributing power are of much more modern origin, and they may partially reverse the tendency to concentration, and enable small workshops and household industries to regain a commercially satisfactory position. Further, to whatever extent facility for conveying power permits the utilisation of new sources of energy, there may be a displacement of industries to new localities. The mountain districts, with abundant water power, may have an advantage over districts where coal is obtained.

Sources of Mechanical Energy.

In these lectures motive power is treated as a commodity, producible, distributable, saleable. The first question is as to the sources from which it can be obtained.

Wind power has been used for driving ships and mills, and now and then it is alleged that, as a source of power, wind action has been too much neglected. But its intermittence restricts its use to work which can be intermittent also. The comparatively short periods in which the wind pressure is a considerable force make it uneconomical to attempt to do more than to utilise very moderate winds. On the other hand, the occasional great intensity of wind action during short periods involves the necessity that structures exposed to its action should be of excessive strength and costliness.

Tidal action might, no doubt, afford an enormous amount of mechanical energy. But up to the present time it has been found that the cost of embankments and machinery for utilising tidal action is so great as to prohibit its employment. The direct action of the sun's heat could be employed, but here, again, the cost of utilisation exceeds the value of the power obtained. Considered practically and commercially, there are only three sources of mechanical energy of industrial importance: 1. The muscular

energy of animals. 2. The gravitation of water falling from a higher to a lower level, and automatically restored to the higher level by the sun. 3. The conversion of heat into mechanical energy, the heat being derived from the combustion of fuels.

As to the muscular energy of animals, the question of distribution does not arise. It is convenient, also, to consider heat energy before considering water power.

Solid Fuel.—By far the most important source of mechanical energy is solid fuel, and chiefly the various descriptions of coal. Coal is obtainable in very many localities, and is transportable anywhere at comparatively small cost. There are, however, certain disadvantages in obtaining energy directly from coal. First of all, there is the fact that, when burned in an open furnace, one fifth to one fourth of the heat escapes with the products of combustion. Next, there is the fundamental disadvantage of the transformation of heat into mechanical energy by a steam-engine, that at most three eights to four fifths of the heat supplied can be transformed, the remainder being rejected in the condenser. The three tenths of the whole heat of the fuel which it is possible to transform by a steam-engine is further reduced by imperfections and losses in the steam engine itself. Then the attendance required in the case of steam engines and boilers, the risk, the difficulty of preventing smoke and of disposing of ashes, are all drawbacks to the general use of steam power.

Gaseous Fuel.—Many of the disadvantages of solid fuel are diminished by employing the coal to produce gas, and using the gas in internal furnace or gas engines. Gas can be transported with great convenience in pipes, and gas engines require less attendance, and work with a greater temperature range and a higher thermal efficiency than steam engines. In transforming heat into work small gas-engines are enormously more efficient than small non-condensing steam engines. On the other hand, ordinary lighting gas, taxed as it is with costs of distribution due to its ordinary application for lighting purposes, is more expensive for a given calorific value than raw coal. The cost of ordinary lighting gas is increased, both by the need of a large generating plant, to meet the excessive fluctuation of demand for lighting, and by the large distributing charges involved in supplying a very great number of small consumers. If gas were made specially for heating and power purposes—either coal gas at low luminous power, or water gas, or producer gas—it could probably be distributed to power users at less than half the present price of coal gas. Used in gas engines, it would then compete, on nearly equal terms as regards cost, with solid coal, and would have many subordinate advantages.

M. Aimé Witz has shown by direct experiment that a gas-engine worked with Dowson gas will give an effective horse power, at a total cost, including all charges for fuel, interest, and depreciation, not greater than that at which an effective horse-power can be obtained by a good boiler and good compound steam-engine. It is impossible to predict how far gas engines will replace steam engines, but at present they have two disadvantages. They are more restricted in size than steam-engines, and they work less economically with light loads.

Production of Power by Burning Town Refuse.—There is another source of heat energy—another fuel—to which Prof. G. Forbes has called special attention—that is, town or ashbin refuse. In addition to ordinary sewage, which is got rid of in well known ways, there is in towns a large quantity of refuse which can only be got rid of effectually and innocuously by burning. Even when the heat generated is wasted, it appears that burning is the least costly method of refuse disposal. It is a fuel, therefore, which, like water power, costs nothing except for the machinery for utilising it.

Various forms of destructors have been tried. It appears that for successful and inoffensive working it is necessary to use a large quantity of air—7lb. or 8lb. per pound of refuse—and that combustion is best effected by a forced draught. Then a large quantity of products of combustion escape from the furnace at a high temperature. By interposing a steam boiler between the furnace and the chimney a by no means unimportant amount of heat can be utilised.

Mr. Watson gives some data of the heat developed in the working of Horsfall furnaces at Leeds, but they are not quite complete or consistent. He states that calculation from an analysis of the escaping gases showed that 4,800lb of water could be evaporated by the heat produced by the combustion of a ton of ashbin refuse. In this calculation it appears that the data assumed were, that in a destructor cell burning six tons of refuse in 24 hours, the escaping gases contained 4·8 per cent. of carbonic acid. The quantity of air passing into the furnace is stated to be 44 tons per day, and the temperature of the gases 2,000deg. The total weight of the furnace gases must then have been 44 + 6 = 50 tons per 24 hours, or say, 4,600lb. per hour; 4·8 per cent. of carbonic acid corresponds to 1·3 per cent. of carbon. Hence the carbon in the furnace gases must have been 0·013 × 4,600 = 59·8lb. per hour. The combustion of this would yield 14,500 × 59·8 = 867,100 thermal units. But also according to the data 4,600lb. of furnace gases were raised from 60deg. to 2,000deg. per hour. This would require 2,231,000 thermal units. These quantities are irreconcileable, and it would seem that either the quantity of air or its temperature have been over estimated. It is true that the heat carried into the furnace by the steam jet has to be deducted from the latter quantity in finding the heat disengaged by the ashbin refuse. From some other experiments it appears that the steam-jet may have delivered 250lb. of steam per cell per hour. The total heat of this would be 287,500 thermal units. If this is deducted from the 2,231,000 thermal units, it still leaves an enormous discrepancy.

Mr. Watson made some other experiments at Oldham. Six cells were used, burning 1½ tons of refuse per hour. The gases passed through a multitubular boiler, 7ft. in diameter and 12ft. long, and the feed was measured by a meter. The temperature of the gases was 2,019deg. before reaching the boiler, and 900deg. after leaving it. Thus only about two-thirds of the available temperature range was utilised. In two trials the mean evaporation was found to be 2,780lb per hour. Deducting 1,500lb. of steam used for the steam-jets, there was a surplus evaporation of 1,280lb. per hour, or, say, 50 h.p. of energy from six cells burning 1½ tons per hour. If a boiler with larger heating surface had been used, possibly an evaporation one third greater would have been obtained, or, say, 3,700lb. per hour. Deducting 1,500lb. used in the steam jets, there would be a surplus or available steam supply of 2,200lb. per hour, or, say, 88 h.p. from six cells burning 1½ tons of refuse per hour. This gives about 40lb. of refuse per effective horse-power hour.

Now the chief difficulty in using the available energy of destructors is this: The refuse must be burned at a regular and almost uniform rate. But demands for power for most purposes are varying demands. It is because later a method of storing heat is to be considered that destructors have been referred to in some detail.

(*To be continued.*)

BLACKPOOL TRAMWAYS.

The number of electrical tramways in this country is so small that little difficulty occurs in watching the working of each one. Just about 12 months ago the Corporation of Blackpool appointed Mr. Hesketh to take charge of the tramway line, and at the end of his first 12 months' appointment he has reported upon his work. The following abstract of accounts, taken from this report, shows approximately the 12 months' working cost and receipts:

APPROXIMATE ABSTRACT OF ACCOUNTS.

(The total car miles from September 9, 1891, to August 22, 1892, were 102,790, and the total traffic receipts for the same period were £6,578. 16s. 1d.)

		1892-3.
Car miles, September 9 to August 22		115,196
Total traffic receipts		£7,033 17 1
Expenditure—		
Wages, traffic	£1,178 1 10	
" office	21 19 6	
" works	224 5 0	
" on repairs to motors	124 4 2	
" " cars	43 11 0	
" " line	218 14 1	
" " switchboard	4 7 0	
		£1,815 2 7
Rents, rates, and taxes		640 4 6
Insurance		3 3 0
Postages and travelling		16 18 4
Printing and stationery		47 4 11½
Coal and coke		261 5 6½
Water and gas		63 15 11
Oil and waste		73 9 5
Station sundries		20 1 8
Materials for repair of engines		13 12 5
" " dynamos		8 15 2
" " switchboard		68 15 3
" " roadway		142 7 10
" " channel		239 17 4
" " motors		232 2 1
" " cars		190 3 6
" " sundries		73 10 8
" " general		1 5 9
		£3,931 15 11
Salaries, engineer	£50 0 0	
Borough treasurer	80 0 0	
		130 0 0
Total		£4,061 15 11

The report explains that to the expenditure shown items for depreciation and sinking fund must be added, and comments upon some of the individual items, such as car miles, receipts, and wages, having increased, but undoubtedly the most important part of the report is that under the head "Suggestions," as follows:

Suggestions.—The committee will pardon my drawing their attention to the following points deserving of their most careful consideration: (*a*) That even with the greatest care and closest supervision the present channel system is not a success; (*b*) that the present method of gearing is far from satisfactory, and should not be continued in any future renewals; (*c*) that a single line cannot be worked without loss of time, and therefore great inefficiency.

To meet these points I venture to suggest that—1. In considering any new system special consideration should be given to (*a*) a centre channel of such construction as Brain's system; or (*b*) to an overhead conductor so arranged as not to offend the eye or appear unsightly, say, for instance, an overhead wire fastened to brackets extended from the promenade arc lamp pillars. 2. That new cars should have a single reduction gearing with V spurs or a worm gearing. The former is the more efficient and, in my opinion, the better system. 3. The question of a double line ca[illegible] tained until the scheme for widening the prome[illegible]

We only note that these sugg[illegible] experience, and they are empha[illegible]

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CONTENTS.

TO CORRESPONDENTS.

 Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

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THE OTHER SIDE.

That Prof. J. S. Burdon-Sanderson would deliver an interesting, if not a memorable, address at Nottingham was to be expected. With this address as a whole we have nothing to do. It is outside our particular domain, and had it not contained an aside with which we disagree, we should not have commented upon it. Prof. Burdon-Sanderson in an aside once or twice in his address trespassed upon a topic with which the public is not unfamiliar, and which seems to have a peculiar fascination for certain scientific men, many, if not most of whom, are constant patrons of the British Association. Their cry, consistent and persistent, is: Let us dip our hands into the public purse. This is how Prof. Sanderson puts it: "The wealthiest country in the world, which has profited more—vastly more—by science than any other, England stands alone in the discredit of refusing the necessary expenditure for its development, and cares not that other nations should reap the harvest for which her own sons have laboured." The president then went on to press the claims of physicists and of chemists, and later of biologists, to laboratories endowed by the State. Of course, these laboratories are to be "on a scale commensurate with the practical importance" of each science. Ordinarily, the Governments of England have been vilified as stingy, as uninterested and deaf to the claims of science. Prof. Sanderson is not so bad as some of the speakers at these meetings. He is not more than half-hearted in his advocacy, and we think few people who have studied the question will agree to go even as far as he does. Do these men who urge this and that Government grant ever trouble to compare the position of England with the position of those places they dangle before us as edifying? Has England done nothing for science? What of Greenwich, what of the Geological Survey, what of Kew, what of the "Challenger" and similar expeditions, what of its laboratories at Kensington, its grants here, and there, and everywhere? Look, again, at her educational endowments. Is it so necessary for the State to maintain schools, when there are so many richly-endowed universities, colleges, and schools? Are our professors paid for giving so many lectures, or are they supposed to be investigators as well? What are the fellowships of our universities provided for if it be not to enable men who have shown talent to continue their studies? Who are these men who want a physical, a chemical, a biological laboratory? Have they no opportunities to experiment now? Is it likely the nation is going to equip and endow laboratories for eager young men to carry on experiments at someone else's cost, and to run off to the Patent Office to patent the results obtained? Many of the very men who advocate national laboratories are the very men who degrade science and drag it to the dust. They are satisfied with nothing, and claim for their miserable discoveries an infallibility that renders them the laughing-stock of business men. It is not for the good of science or the welfare of humanity, it is not from a patriotic love of country that these men cry "Give! give!" Their only desire is

to line their own pockets at the least trouble to themselves. We are quite sure Prof. Sanderson has not viewed the question in this light. In the quiet, peaceful shade of the university he has learned to love science for the sake of science, can see how with certain facilities more can be done, but he has yet to live in the centre of the business part of the kingdom, and hear how emphatically and universally the proceedings of the younger race of professors, and especially of those with a leaning towards physics, are condemned. How can Prof. Sanderson urge a biological laboratory when his views of the subject are expressed in these words: "I think it not unlikely that the only effect of what I have said may be to suggest to some of my hearers the question, What is the use of such enquiries? Experimental psychology has, to the best of my knowledge, no technical application. The only satisfactory answer I can give is that it has exercised, and will exercise in future, a helpful influence in the science of life." In another part of this address we are told: "It is possible that many members of the association are not aware of the unfavourable, I will not say discreditable, position that this country at present occupies in relation to the scientific study of this great subject—the causes, and mode of prevention of infectious diseases." This is another insinuation with which we disagree. England is not so behindhand as is made out, and when it comes to practical work England is not at all behind. It may be very well to hint that Pasteur and others have made a great fuss about inoculation, but as a matter of fact none of the inoculists or microbe investigators have satisfied the world as to their theories or actions. Tell the truth about these matters. If an Englishman suggests in his modest way some new views nobody takes any notice of him. His own countrymen, instead of testing the value of these views, won't look at them, and wait for a boom from France or Germany. We think we know pretty fairly the sanitary conditions of continental towns, and in our opinion that condition is, on the whole, far and away inferior to that of English towns. This to us is sufficient proof that England is not one whit inferior in sanitary knowledge, and, what is more, in sanitary practice, to other nations. Lastly, we differ entirely to the conclusions that the earnest science student's question "is ever 'how,' rather than 'why.'" He is no true student if he does not prefer the "why" to the "how." When he knows the "why" he may be able to influence the "how"; but till he can do that, his studies, his knowledge, and his labours are lost.

It would come better before the public if this agitation for laboratories came from other sources. Have, for example, the steel, iron, and other manufacturers in metals asked for a physical laboratory; have the cotton or woollen manufacturers, the dyers, the papermakers asked for a chemical laboratory; have medical men or sanitarians asked for a biological laboratory? Do these men not recognise the paucity of knowledge, or is such recognition only to be found among a few professors, some of whom want berths for themselves or their friends? One in a million improvements in industrial operations may come from professorial laboratory work, but as a matter of fact the remainder come from the factory. The men in the latter from day to day know what they want, and try to solve the problem put before them by that want; the men in the laboratory imagine that whatever they do is wanted. The real wants of the factory do not come before them, and never will, unless we come to the old-womanish legislation that seems to be prevailing at present, when the State does everything. The manufacturer wants to know himself, and use his knowledge; he is not so anxious that all his competitors should know, and not at all anxious to give every problem to a central body to solve and publish broadcast. There is a mistaken idea about that a national laboratory will lead to discoveries that may revolutionise industrial operations. Such discoveries have been made; but most improvements are of a different character, and are due to the men continually engaged in the industry. What is to be the definite work of these proposed laboratories? Greenwich provides the nautical almanack; the Geological Survey and Kew provide definite information. This provision of definite information constitutes a difference between these and laboratories which would have merely a roving commission.

REVIEWS.

Elementary Lessons, with Numerical Examples in Practical Mechanics and Machine Design. By R. G. BLAINE, M.E. New edition. Cassell and Co.

Prof. Perry, in his introduction to Mr. Blaine's book, has a sentence referring to authors of books on mechanical subjects which we much appreciate. He says: "It is perfectly well known that the sort of knowledge which such authors try to give is treated with a certain amount of contempt by all practical engineers." This book has an object: to assist the scheme of teaching at the Finsbury Technical College, where we are told two lectures are followed by two hours' numerical work, which again is followed by three hours' laboratory work per week. Mr. Blaine has collected in this book notes of lectures or lessons, and numerical examples based thereon—principally numerical examples. These, we are told, and so far as we have examined them told truly, are of a very practical nature, intended to be similar to those the student will meet with in practical work. We could wish there were more books of the kind, for we are assured that exactness in mental conception is greatly assisted by constant solution of numerical examples. Without such paper work the student thinks loosely rather than accurately. He is totally unable to shake off and consign to oblivion those things that concern him not, and for ever he fears to run alone. The examples given in this book could with advantage be largely extended. Only one short section deals with electrical subjects, and we cannot quite determine the claim for new matter in this section, the numerical examples being under a dozen. The value of the book is, however, not in one section, but as a whole, treating shortly, as it does in the notes, and by a number of numerical examples, a very large range of subjects coming under the head of mechanical engineering.

Gas and Electric Light.—Mr F. L. Linging told the shareholders of the Crystal Palace District Gas Company last week that the competition of the electric light and oil had made no difference to the company during the past half-year.

THE BRITISH ASSOCIATION.

On Wednesday the sixty-third session of the British Association commenced its labours at Nottingham with the presidential address of Prof. J. S. Burdon Sanderson. The address is of great interest to that section of scientific workers whose labours are devoted to biological studies, and bad it not advocated the initiation of laboratories under State aid—a subject dealt with elsewhere—we could have found no words but of praise for this address. As usual, the presidents of Sections A and G in their addresses dealt with subjects not widely separated from electrical matters—in fact, very closely related to them, and these addresses we herewith reproduce :

Address to the Mathematical and Physical Section.

BY R. T. GLAZEBROOK, M.A., F.R.S., PRESIDENT OF THE SECTION.

Before dealing with the subject which I hope to bring to your notice this morning, I wish to express my deep regret for the circumstances which have prevented Prof. Clifton, who had accepted the nomination of the council, from being your president this year. It was specially fitting that he who has done so much for this college, and particularly for this laboratory in which we meet, should take the chair at Nottingham. The occasions on which we see him are all too seldom ; and we who come frequently to these meetings were looking forward to help and encouragement in our work, derived from his wide experience. You would desire, I feel sure, that I should convey to him the expressions of your sympathy. For myself I must ask that you will pass a lenient judgment on my efforts to fill his place. Let me commence, then, with a brief retrospect of the past year and the events which concern our section. From the days of Galileo the four satellites of Jupiter have been objects of interest to the astronomer. Their existence was one of the earliest of the discoveries of the telescope, they proved conclusively that all the bodies of the solar system did not move round the earth. The year which has passed since our last meeting is memorable for the discovery of a fifth satellite. It is a year to-day (September 13-14, 1892) since Prof. Barnard convinced himself that he had seen with the great telescope of the Lick Observatory this new member of our system as a star of the thirteenth magnitude, revolving round the planet in 11 hours 57 minutes 23 seconds.*

The conference on electrical standards held at our meeting last year has had important results. The resolutions adopted at Edinburgh were communicated to the Standards Committee of the Board of Trade. A supplementary report accepting these resolutions was agreed to by that committee (November 29, 1892), and presented to the President of the Board of Trade. The definitions contained in this report will be made the basis of legislation throughout the world. They have been accepted by France, Germany, Austria, and Italy. There is good reason to believe that the congress at Chicago now being held will ratify them, and then we may claim that your committee, co-operating with the leaders of physical science in other lands, has secured international agreement on these fundamental points. Among the physical papers of the year I would mention a few as specially calling for notice. Mr. E. H. Griffith's redetermination of the value of the mechanical equivalent of heat has just been published,† and is a monumental work. With untiring energy and great ability he struggled for five years against the difficulties of his task, and has produced results which, with the exception of one group of experiments, do not differ by more than one part in 10,000, while the results of that one excepted group differ from the mean only by one part in 4,000. The number of ergs of work required to raise one gramme of water 1deg. C. at 15deg. C. is $4{\cdot}194 \cdot 10^7$. Expressed in foot-pounds and Fahrenheit degrees, the value of J is 778·99. The value obtained by Joule from his experiments on the friction of water, when corrected in 1880 by Rowland so as to reduce his readings to the air thermometer, is 778·5 at 12deg. 7 C. The result at this temperature of Rowland's own valuable research is 780·1. Another satisfactory outcome of Mr. Griffith's work is the very exact accordance between the scale of temperature as determined by the comparison of his platinum thermometer with the air thermometer, which was made by Callendar and himself in 1890, and that of the nitrogen thermometer of the Bureau International at Sèvres.

Another great work now happily complete is Rowland's "Table of Standard Wave-lengths."‡ Nearly a thousand lines have been measured with the skill and accuracy for which Rowland has made himself famous ; and in this table we see the results achieved by the genius which designed the concave grating and the mechanical ingenuity which contrived the almost perfect screw. Those of us who have seen Mr. Higgs's wonderful photographs of the solar spectrum taken with a Rowland grating will rejoice to know that his map also is now finished. Lord Rayleigh's paper on "The Intensity of Light Reflected from Water and Mercury at Nearly Perpendicular Incidence,"§ combined with the experiments on reflection from liquid surfaces in the neighbourhood of the polarising angle,‖ establishes results of the utmost importance to optical theory. "There is thus," Lord Rayleigh concludes, "no experimental evidence against the rigorous application of Fresnel's formulæ,"—for the reflection of polarised light—"to the ideal case of an abrupt transition between two uniform transparent media." Prof. Dewar has, during the year, continued his experiments on the liquefaction of oxygen and nitrogen on a large scale. To a physicist perhaps the most important results of the research are the discovery of the magnetic properties of liquid oxygen, and the proof of the fact that the resistance of certain pure metals vanishes at absolute zero.* The last discovery is borne out by Griffiths and Callendar's experiments with their platinum thermometers.† Mr. Williams's article on "The Relation of the Dimensions of Physical Quantities to Directions in Space,"‡ has led to an interesting discussion. Some of his deductions will be noticed later. The title-page of the first edition of Maxwell's "Electricity and Magnetism" bears the date 1873. This year, 1893, we welcome a third edition, edited by Maxwell's distinguished successor, and enriched by a supplementary volume, in which Prof. J. J. Thomson describes some of the advances made by electrical science in the last 20 years. The subject-matter of this volume might well serve as a text for a presidential address.

The choice of a subject on which to speak to-day has been no easy task. The field of physics and mathematics is a wide one. There is one matter, however, to which for a few minutes I should like to call your attention, inadequately though it be. Optical theories have, since the year 1876, when I first read Sir George Stokes's "Report on Double Refraction,"§ had a special interest for me, and I think the time has come when we may with advantage review our position with regard to them, and sum up our knowledge. That light is propagated by an undulatory motion through a medium which we call the ether is now an established fact, although we know but little of the nature or constitution of the ether. The history of this undulatory theory is full of interest, and has, it appears to me, in its earlier stages been not quite clearly apprehended. Two theories have been proposed to account for optical phenomena. Descartes was the author of the one—the emission theory. Hooke, though his work was very incomplete, was the founder of the undulatory theory. In his "Micrographia," 1664, page 56, he asserts that light is a quick and short vibratory motion, "propagated every way through an homogeneous medium by direct or straight lines extended every way like rays from the centre of a sphere. . . . Every pulse or vibration of the luminous body will generate a sphere which will continually increase and grow bigger, just after the same manner, though indefinitely swifter, as the waves or rings on the surface do swell into bigger and bigger circles about a point on it" ; and he gives on this hypothesis an account of reflexion, refraction, dispersion, and the colours of thin plates. In the same work, page 58, he describes an experiment practically identical with Newton's famous prism experiment, published in 1672. Hooke used for a prism a glass vessel about 2ft. long, filled with water, and inclined so that the sun's rays might enter obliquely at the upper surface and traverse the water. "The top surface is covered by an opacous body, all but a hole through which the sun's beams are suffered to pass into the water, and are thereby refracted" to the bottom of the glass, "against which part if a paper be expanded on the outside there will appear all the colours of the rainbow—that is, there will be generated the two principal colours, scarlet and blue, with all the intermediate ones which arise from the composition and dilating of these two." But Hooke could make no use of his own observation ; he attempted to substantiate it from his own theory of colours, and wrote pure nonsense in the attempt ; and though his writings contain the germ of the theory, and in the light of our present knowledge it seems possible that he understood it more thoroughly than his contemporaries believed, yet his reasoning is so utterly vague and unsatisfactory that there is little ground for surprise that he convinced but few of its truth. And then came Newton. It is claimed for him, and that with justice, that he was the true founder of the emission theory. In Descartes's hands it was a vague hypothesis. Newton deduced from it by rigid reasoning the laws of reflexion and refraction, he applied it with wondrous ingenuity to explain the colours of thin and of thick plates and the phenomena of diffraction, though in doing this he had to suppose a mechanism which he must have felt to be almost impossible, a mechanism which in time, as it was applied to explain other and more complex phenomena, became so elaborate that, in the words of Verdet, referring to a period 100 years later, "all that is necessary to overturn this laborious scaffolding is to look at it and try to understand it." But though Newton may with justice be called the founder of the emission theory, it is unjust to his memory to state that he accepted it as giving a full and satisfactory account of optics as they were known to him. When he first began his optical work he realised that facts and measurements were needed, and his object was to furnish the facts. He may have known of Hooke's theories. The copy of the "Micrographia" now at Trinity College was in the library while Newton was working with his prism in rooms in college, and may have been consulted by him. An early note-book of his contains quotations from it. Still, there was nothing in the theories but hypotheses unsupported by facts, and these would have no charm for Newton. The hypotheses in the main are

* "In general," he says, "the satellite has been faint. . . . On the 13th, however, when the air was very clear, it was quite easy."—*Nature*, Oct. 20, 1892. † *Phil. Trans.*, vol. clxxxiv. ‡ *Phil. Mag.*, July, 1893. § *Ibid.*, Oct., 1892. ‖ *Ibid.*, Jan., 1892.

* *Phil. Mag.*, September, 1892. ‡ *Ibid.*, December, 1892.
† *Ibid.*, October, 1892. § *British Association Report*, 1862.

This address was in the printer's hands when I saw Sir G. Stokes's paper on "The Luminiferous Ether," *Nature*, July 27. Had I known that so great a master of my subject had dealt with it so lately, my choice might have been different ; under the circumstances, it was too late to change.

right. Light is due to wave motion in an all-pervading ether; the principle of interference, vaguely foreshadowed by Hooke ("Micrographia," p. 66), was one which a century later was to remove the one difficulty which Newton felt. For there was one fact which Hooke's theory could not then explain, and till that explanation was given the theory must be rejected; the test was crucial, the answer was decisive. Newton tells us repeatedly what the difficulty was. In reply to a criticism of Hooke's in 1672, he writes: "For to me the fundamental supposition itself seems impossible namely, that the waves or vibrations of any fluid can, like the rays of light be propagated in straight lines without continual and very extravagant spreading and bending into the quiescent medium where they are terminated by it. I mistake if there be not both experiment and demonstration to the contrary. . . . For it seems impossible that any of those motions or pressions can be propagated in straight lines without the like spreading every way into the shadowed medium." Nor was there anything in the controversy with Hooke, which took place about 1675, to shake this belief. Hooke had read his paper describing his discovery of diffraction. He had announced it two years earlier, and there is no doubt in my mind that this was an original discovery, and not, as Newton seemed to imply soon after, taken from Grimaldi; but his paper does not remove the difficulty. Accordingly we find in the "Principia" Newton's attempted proof (lib. ii prop. 42) that "motus omnis per fluidum propagatus divergit a recto tramite in spatia immota"—a demonstration which has convinced but few and leaves the question unsolved as before. Again, in 1690 Huygens puplished his great "Traite de la Lumiere," written in 1678. Huygens had clearer views than Hooke on all he wrote; many of his demonstrations may be given now as completely satisfactory, but on the one crucial matter he was fatally weak. He, rather than Hooke, is the true founder of the undulatory theory, for he showed what it would do if it could but explain the rectilinear propagation. The reasoning of the latter part of Huygens's first chapter becomes forcible enough when viewed in the light of the principle of interference enunciated by Young, November 12, 1801, and developed, independently of Young, by Fresnel in his great memoir on "Diffraction," in 1815; but without this aid it was not possible for Huygens's arguments to convince Newton, and hence in the "Opticks" (second edition, 1717) he wrote the celebrated Query 28: "Are not all hypotheses erroneous in which light is supposed to consist in pressure or motion propagated through a fluid medium? If it consisted in motion propagated either in an instant or in time it would bend into the shadow. For pressure or motion cannot be propagated in a fluid in right lines beyond an obstacle which stops part of the motion, but will bend and spread every way into the quiescent medium which lies outside the shadow." These were his last words on the subject. They prove that he could not accept the undulatory theory; they do not prove that he believed the emission theory to give the true explanation. Yet, in spite of this, I think that Newton had a clearer view of the undulatory theory than his contemporaries, and saw more fully than they did what the theory could achieve if but the one difficulty were removed. This was Young's belief, who writes: *"A more extensive examination of Newton's various writings has shown me that he was in reality the first who suggested such a theory as I shall endeavour to maintain; that his own opinions varied less from this theory than is now almost universally believed; and that a variety of arguments have been advanced as if to meet him which may be found in a nearly similar form in his own works." I wish to call attention to this statement, and to bring into more prominent view the grounds on which it rests, to place Newton in his true position as one of the founders of the undulatory theory.

The emission theory in Newton's hands was a dynamical theory; he traced the motion of material particles under certain forces, and found their path to coincide with that of a ray of light, and in the "Principia," prop. xcvi., Scholium, he calls attention to the similarity between these particles and light. The particles obey the laws of reflexion and refraction; but to explain why some of the incident light was reflected and some refracted Newton had to invent his hypothesis of fits of easy reflexion and transmission. These are explained in the "Opticks," book iii., props. xi., xii., and xiii. (1,704), thus: "Light is propagated from luminous bodies in time, and spends about seven or eight minutes of an hour in passing from the sun to the earth. Every ray of light in its passage through any refracting surface is put into a certain transient constitution or state, which in the progress of the ray returns at frequent intervals, and disposes the ray at each return to be easily transmitted through the next refracting surface, and between the returns to be easily reflected by it. *Definition.*—The return of the disposition of any ray to be reflected I will call its fit of easy reflexion, and those of the disposition to be transmitted its fits of easy transmission, and the space it passes between every return and the next return the interval of its fits. The reason why the surfaces of all thick transparent bodies reflect part of the light incident on them and refract the rest, is that some rays at their incidence are in their fits of easy reflexion, some in their fits of easy transmission."

Such was Newton's theory. It accounts for some or all of the observed facts, but what causes the fits? Newton, in the "Opticks," states that he does not enquire; he suggests, for those who wish to deal in hypotheses, that the rays of light striking the bodies set up waves in the reflecting or refracting substance which move faster than the rays and overtake them. When a ray is in that part of the vibration which conspires with its motion it easily breaks through the refracting surface—it is in a fit of easy transmission; and, conversely, when the motion of the ray and the wave are opposed, it is in a fit of easy reflection. But he was not always so cautious. At an earlier date (1675) he sent to Oldenburg, for the Royal Society, an "Hypothesis explaining the Properties of Light"; and we find from the journal book that "these observations so well pleased the society that they ordered Mr. Oldenburg to desire Mr. Newton to permit them to be published." Newton agreed, but asked that publication should be deferred till he had completed the account of some other experiments which ought to precede those he had described. This he never did, and the hypothesis was first printed in Birch's "History of the Royal Society," vol. iii., pp. 247, 262, 272, etc.; it is also given in Brewster's "Life of Newton," vol. i., App. II., and in the *Phil. Mag.*, September, 1846, pp. 187-213. "Were I," he writes in this paper, "to assume an hypothesis, it should be this if propounded more generally, so as not to assume what light is further than that it is something or other capable of exciting vibrations of the ether. First, it is to be assumed that there is an ethereal medium, much of the same constitution with air, but far rarer, subtiller, and more strongly elastic. . . . In the second place, it is to be supposed that the ether is a vibrating medium, like air, only the vibrations far more swift and minute; those of air made by a man's ordinary voice succeeding at more than half a foot or a foot distance, but those of ether at a less distance than the hundred-thousandth part of an inch. And as in air the vibrations are some larger than others but yet all equally swift . . . . so I suppose the ethereal vibrations differ in bigness but not in swiftness. . . . In the fourth place, therefore, I suppose that light is neither ether nor its vibrating motion, but something of a different kind propagated from lucid bodies. They that will may suppose it an aggregate of various peripatetic qualities. Others may suppose it multitudes of unimaginable small and swift corpuscles of various sizes springing from shining bodies at great distances one after the other, but yet without any sensible interval of time. . . . To avoid dispute and make this hypothesis general let every man here take his fancy; only, whatever light be, I would suppose it consists of successive rays differing from one another in contingent circumstances, as bigness, force, or vigour, like as the sands on the shore . . . . and, further, I would suppose it diverse from the vibrations of the ether. . . . Fifthly, it is to be supposed that light and ether mutually act upon one another." It is from this action that reflexion and refraction come about; "ethereal vibrations are, therefore," he continues, "the best means by which such a subtile agent as light can shake the gross particles of solid bodies to heat them. And so, supposing that light impinging on a refracting or reflecting ethereal superficies puts it into a vibrating motion, that physical superficies being by the perpetual appulse of rays always kept in a vibrating motion, and the ether therein continually expanded and compressed by turns, if a ray of light impinge on it when it is much compressed, I suppose it is then too dense and stiff to let the ray through, and so reflects it, but the rays that impinge on it at other times, when it is either expanded by the interval between two vibrations or not too much compressed and condensed, go through and are refracted. . . . And now to explain colours. I suppose that as bodies excite sounds of various tones, and consequently vibrations in the air of various bignesses, so when the rays of light, by impinging on the stiff refracting superficies, excite vibrations in the ether, these rays excite vibrations of various bignesses . . . therefore, the ends of the capillaments of the optic nerve which front or face the retina being such refracting superficies, when the rays impinge on them they must there excite these vibrations, which vibrations (like those of sound in a trumpet) will run along the aqueous pores or crystalline pith of the capillaments through the optic nerves into the sensorium (which light itself cannot do), and there, I suppose, affect the sense with various colours, according to their bigness and mixture—the biggest with the strongest colours, reds and yellows; the least with the weakest, blues and violets; the middle with green; and a confusion of all with white." The last idea, the relation of colour to the bigness of wave length, is put even more plainly in the "Opticks," Query 13 (ed. 1704): "Do not several sorts of rays make vibrations of various bignesses, which according to their bignesses excite sensations of various colours . . . and, particularly, do not the most refrangible rays excite the shortest vibrations for making a sensation of deep violet; the least refrangible the largest for making a sensation of deep red?"

The whole is but a development of a reply, written in 1672, to a criticism of Hooke's on his first optical paper, in which Newton says: "It is true that from my theory I argue the corporeity of light, but I do it without any absolute positiveness, as the word perhaps intimates, and make it at most a very plausible consequence of the doctrine and not a fundamental supposition." "Certainly," he continues, "my hypothesis has a much greater affinity with his own (Hooke's) than he seems to be aware of, the vibrations of the ether being as useful and necessary in this as in his." Thus Newton, while in the "Opticks" he avoided declaring himself as to the mechanism by which the fits of easy reflection and transmission were produced, has in his earlier writings developed a theory practically identical in many respects with modern views, though without saying that he accepted it. It was an hypothesis; one difficulty remained, it would not account for the rectilinear propagation, and it must be rejected till it did. Light is neither ether nor its vibrating motion; it is energy which emitted from luminous bodies, is carried by wave motion in rays, and falling on a reflecting surface sets up fresh waves by which it is in part transmitted and in part reflected. Light is not material, but Newton nowhere definitely asserts that it is. He "argues the corporeity of light, but without any absolute positiveness."

* *Phil. Trans.*, November 12, 1801.

the "Principia" writing of his particles, his words are: "Harum attractionum haud multum dissimiles, sunt Lucis reflexiones et refractiones"; and the Scholium concludes with: "Igitur ob analogiam quæ est inter propagationem radiorum lucis et progressum corporum, visum est propositiones sequentes in usus opticos subjungere; interea de natura radiorum utrum sint corpora necne nihil omnino disputans, sed trajectorias corporum trajectoriis radiorum persimiles sollummodo determinans."* No doubt Newton's immediate successors interpreted his words as meaning that he believed in the corpuscular theory, conceived, as Herschel says, by Newton, and called by his illustrious name. Men learnt from the "Principia" how to deal with the motion of small particles under definite forces. The laws of wave motion were obscure, and till the days of Young and Fresnel there was no second Newton to explain them. There is truth in Whewell's words ("Inductive Sciences," ii., chap. x.): "That propositions existed in the 'Principia' which proceeded on this hypothesis was with many ground enough for adopting the doctrine." Young's view, already quoted, appears to me more just; and I see in Newton's hypothesis the first clear indication of the undulatory theory of light, the first statement of its fundamental laws. Three years later (1678), Huygens wrote his "Traité de la Lumière," published in 1690. He failed to meet the main difficulty of the theory, but in other respects he developed its consequences to a most remarkable degree. For more than a century after this there was no progress, until in 1801 the principle of interference was discovered by Young, and again independently a few years later by Fresnel, whose genius triumphed over the difficulties to which his predecessors had succumbed, and by combining the principles of interference and transverse vibrations, established an undulatory theory as a fact, thus making Newton's theory a *vera causa*.

There is, however, a great distinction between the emission theory as Newton left it and Fresnel's undulatory theory. The former was dynamical, though it could explain but little; the particles of light obeyed the laws of motion, like particles of matter. The undulatory theory of Huygens and Fresnel was geometrical or kinematical; the structure of the ether was and is unknown; all that was needed was that light should be due to the rapid periodic changes of some vector property of a medium capable of transmitting transverse waves. Fresnel, it is true, attempted to give a dynamical account of double refraction, and of the reflexion and refraction of polarised light, but the attempt was a failure; and not the least interesting part of Mr. L. Fletcher's recent book on double refraction ("The Optical Indicatrix") is that in which he shows that Fresnel himself in the first instance arrived at his theory by purely geometrical reasoning, and only attempted at a later date to give it its dynamical form. "If we reflect," says Stokes,† "on the state of the subject as Fresnel found it and as he left it, the wonder is, not that he failed to give a rigorous dynamical theory, but that a single mind was capable of effecting so much." Every student of optics should read Fresnel's great memoirs. But the time was coming when the attempt to construct a dynamical theory of light could be made. Navier, in 1821, gave the first mathematical theory of elasticity. He limited himself to isotropic bodies, and worked on Boscovitch's hypothesis as to the constitution of matter. Poisson followed on the same lines, and the next year (1822) Cauchy wrote his first memoir on elasticity. The phenomena of light afforded a means of testing this theory of elasticity, and accordingly the first mechanical conception of the ether was that of Cauchy and Neumann, who conceived it to consist of distinct hard particles acting upon one another with forces in the line joining them, which vary as some function of the distances between the particles. It was now possible to work out a mechanical theory of light which should be a necessary consequence of these hypotheses. Cauchy's and the earlier theories do not represent the facts either in an elastic solid or in the ether. At present we are not concerned with the cause of this; we must recognise it as the first attempt to explain on a mechanical basis the phenomena observed. According to his theory in its final form, there are, in an isotropic medium, two waves which travel with velocities $\sqrt{A/\rho}$ and $\sqrt{B/\rho}$, A and B being constants and ρ the density. Adopting Cauchy's molecular hypothesis, there must be a definite relation between A and B. A truer view of the theory of elasticity is given by Green in his paper read before the Cambridge Philosophical Society in 1837. This theory involves the two constants, but they are independent, and to account for certain optical effects A must either vanish or be infinite. The first supposition was, until a few years since, thought to be inconsistent with stability; the second leads to consequences which in part agree with the results of optical experiment, but which differ fatally from those results on other points. And so the first attempt to construct a mechanical theory of light failed. We have learnt much from it. At the death of Green the subject had advanced far beyond the point at which Fresnel left it. The causes of the failure are known, and the directions in which to look for modifications have been pointed out.

Now, I believe that the effort to throw any theory into mechanical form, to conceive a model which is a concrete representation of the truth, to arrive at that which underlies our mathematical equations wherever possible, is of immense value to every student. Such a course, I am well aware, has its dangers. It may be thought that we ascribe to the reality all the properties of the model, that, in the case of the ether, we look upon it as a collection of gyrostatic molecules and springs, or of pulleys and indiarubber bands, instead of viewing it from the standpoint of Maxwell, who hoped, writing of his own model, "that by such mechanical fictions anyone who understands the provisional and temporary character of his hypothesis will find himself helped rather than hindered in his search after the true interpretation of the phenomena." Prof. Boltzmann, in his most interesting paper on "The Methods of Theoretical Physics,"* has quoted these words, and has expressed far more ably than I can hope to do the idea I wish to convey. The elastic solid theory, then, has failed; but are we therefore without any mechanical theory of light? Are we again reduced to merely writing down our equations, and calling some quantity which appears in them the amplitude of the light vibration and the square of that quantity the intensity of the light? Or can we take a further step? Let us enquire what the properties of the ether must be which will lead us by strict reasoning to those equations which we know represent the laws of the propagation of light. These equations resemble in many respects those of an elastic solid; let us, then, for a moment identify the displacement in a light wave with an actual displacement of a molecule of some medium having properties resembling that of a solid. Then this medium must have rigidity or quasi rigidity in order that it may transmit transverse waves; at the same time it must be incapable of transmitting normal waves, and this involves the supposition that the quantity, A, which appears in Green's equations must vanish or be infinite. To suppose it infinite is to recur to the incompressible solid theory; we will assume, therefore, that it is zero. Reflexion and refraction show us that the ether in a transparent medium, such as glass, differs in properties from that in air. It may differ either (1) in density or effective density† or (2) in rigidity or effective rigidity. The laws of double refraction and the phenomena of the scattering of light by small particles show us that the difference is, in the main, in density or effective density; the rigidity of the ether does not greatly vary in different media. Dispersion, absorption, and anomalous dispersion all tell us that in some cases energy is absorbed from the light vibrations by the matter through which they pass, or, to be more general, by something very intimately connected with the matter. We do not know sufficient to say what that action must be; we can, however, try the consequences of various hypotheses. Guided by the analogy of the motion of a solid in a fluid let us assume that the action is proportional to the acceleration of the ether particles relative to the matter, and, further, that under certain circumstances some of the energy of the ether particles is transferred to the matter, thus setting them in vibration. If such action be assumed, the actual density of the ether may be the same in all media, the mathematical expression for the forces will lead to the same equations as those we obtain by supposing that there is a variation of density, and since it is clearly reasonable to suppose that this action between matter and ether is in a crystal a function of the direction of vibration, the apparent or effective density of the ether in such a body will depend on the direction of displacement.

Now these hypotheses will conduct us by strict mathematical reasoning to laws for the propagation, reflexion, and refraction, double refraction and polarisation, dispersion, absorption, and anomalous dispersion and aberration of light which are in complete accordance with the most accurate experiments. The rotary polarisation of quartz, sugar, and other substances points to a more complicated action between the ether and matter than is contemplated above, and accordingly, other terms have to be introduced into the equations to account for these effects. It will be noted as a defect, and perhaps a fatal one, that the connection between electricity and light is not hinted at, but I hope to return to that point shortly. Such a medium as I have described is afforded us by the labile ether of Lord Kelvin. It is an elastic solid or quasi solid incapable of transmitting normal waves. The quantity, A, is zero, but Lord Kelvin has shown that the medium would still be stable provided its boundaries are fixed, or, which comes to the same thing, provided it extends to infinity. Such a medium would collapse if it were not held fixed at its boundaries but if it be held fixed, and if then all points on any closed spherical surface in the medium receive a small normal displacement, so that the matter within the surface is compressed into a smaller volume, there will be no tendency either to aid or to prevent this compression, the medium in its new state will still be in equilibrium, the stresses in any portion of it which remains unaltered in shape are independent of its volume, and are functions only of the rigidity and implicity of the forces which hold the boundary of the whole medium fixed. A soap film affords in two dimensions an illustration of such a medium; the tension at any point of the film does not depend on the dimensions; we may suppose the film altered in area in any way we please—so long as it remains continuous—without changing the tension. Waves of displacement parallel to the surface of the film would not be

* The reflexions and refractions of light are not very unlike these attractions. Therefore, because of the analogy which exists between the propagation of rays of light and the motion of bodies, it seemed right to add the following propositions for optical purposes, not at all with any view of discussing the nature of rays (whether they are corporeal or not), but only to determine paths of particles which closely resemble the paths of rays.—"Principia," lib. i., sect. xiv., prop. xcvi., Scholium.

† "Report on Double Refraction," British Association Report, 1862, p. 254.

* *Phil. Mag.*, July, 1893.

† The equations of motion for a medium such as is supposed above can be written: ρ × acceleration of ether + ρ' × acceleration of matter = Σ B × function of ether displacements, and their differential coefficients with respect to the co-ordinates + Σ B' × similar function for matter displacements. The quantity ρ may be spoken of as the effective ether density, the quantities B as the effective elasticity or rigidity.

transmitted But such a film in consequence of its tension has an apparent rigidity for displacements normal to its surface: it can transmit transverse waves with a velocity which depends on the tension. Now the labile ether is a medium which has, in three dimensions, characteristics resembling those of the two-dimensional film. Its fundamental property is that the potential energy per unit volume in an isotropic body, so far as it arises from a given strain, is proportional to the square of the resultant twist In an incompressible elastic ether this potential energy depends upon the shearing strain. Given such a medium and there is nothing impossible in its conception the main phenomena of light follow as a necessary consequence. We have a mechanical theory by the aid of which we can explain the phenomena; we can go a few steps behind the symbols we use in our mathematical processes Lord Kelvin, again has shown us how such a medium might be made up of molecules having rotation in such a way that it could not be distinguished from an ordinary fluid in respect to any irrotational motion, it would, however, resist rotational movements with a force proportional to the twist, just the force required; the medium has no real rigidity. but only a quasi rigidity conferred on it by its rotational motion. The actual periodic displacements of such a medium may constitute light. We may claim, then, with some confidence to have a mechanical theory of light. But nowadays the ether has other functions to perform, and there is another theory to consider, which at present holds the field Maxwell's equations of the electromagnetic field are practically identical with those of the quasi-labile ether. The symbols which occur can have an electromagnetic meaning; we speak of permeability and inductive capacity instead of rigidity and density, and take as our variables the electric or magnetic displacements instead of the actual displacement or the rotation. Still, such a theory is not mechanical. Electric force acts on matter charged with electricity and the ratio of the force to the charge can be measured in mechanical units. A fundamental conception in Maxwell's theory is electric displacement, and this is proportional to the electric force Moreover, its convergence measures the quantity of electricity present per unit volume, but we have no certain mechanical conception of electric displacement or quantity of electricity, we have no satisfactory mechanical theory of the electromagnetic field. The first edition of the "Electricity and Magnetism" appeared 20 years ago In it Maxwell says: "It must be carefully borne in mind that we have made only one step in the theory of the action of the medium. We have supposed it to be in a state of stress, but we have not in any way accounted for this stress, or explained how it is maintained This step, however, appears to me to be an important one, as it explains by the action of consecutive parts of the medium phenomena which were formerly supposed to be explicable only by direct action at a distance I have not been able to make the next step namely, to account by mechanical considerations for these stresses in the dielectric." And these words are true still But for all this, I think it may be useful to press the theory of the quasi labile ether as far as it will go, and endeavour to see what the consequences must be. The analogy between the equations of the electromagnetic field and those of an elastic solid has been discussed by many writers. In a most interesting paper on the theory of dimensions, read recently before the Physical Society, Mr Williams has called attention to the fact that two only of these analogies have throughout a simple mechanical interpretation These two have been developed at some length by Mr. Heaviside in his paper in the *Electrician* for January 23rd, 1891 To one of them Lord Kelvin had previously called attention ("Collected Papers," vol. iii., page 450)

Starting with a quasi labile ether, then we may suppose that μ, the magnetic permeability of the medium, is $4\pi\rho$,* where ρ is the density, and that K, the inductive capacity, is $1/4\pi B$, B being the rigidity, or the quasi rigidity conferred by the rotation. The kinetic energy of such a medium is $\frac{1}{2}\rho(\dot{\xi}^2+\dot{\eta}^2+\dot{\zeta}^2)$, where ξ, η, ζ are the components of the displacement. Let us identify this with the electromagnetic energy $(\alpha^2+\beta^2+\gamma^2)/8\pi$, α, β, γ being components of the magnetic force, so that $\alpha=\dot{\xi}$, $\beta=\dot{\eta}$, $\gamma=\dot{\zeta}$. Then the components of the electric displacement, assuming them to be zero initially, are given by

$$f=\frac{1}{4\pi}\left(\frac{d\dot{\zeta}}{dy}-\frac{d\dot{\eta}}{dz}\right), \text{ etc. };$$

that is, the electric displacement, $\mathfrak{D}$, multiplied by 4π is equal to the rotation in the medium. Denote this by Ω. The potential energy due to the strain is

$$\tfrac{1}{2}B\Omega^2, \text{ or } \tfrac{1}{2}16\pi^2 B\mathfrak{D}^2;$$

and on substituting for B this becomes

$$\frac{1}{2}\frac{4\pi}{K}\mathfrak{D}^2,$$

which is Maxwell's expression for the electrostatic energy of the field Thus, so far, but no farther, the analogy is complete, the kinetic energy of the medium measures the magnetic energy, the potential energy measures the electrostatic energy. The stresses in the ether, however, are not those given by Maxwell's theory.

In the other form of the analogy we are to take the inductive capacity as $4\pi\rho$, and the magnetic permeability as $1/4\pi B$. The velocity measures the electric force, and the rotation the magnetic force, so that electrostatic energy is kinetic, and magnetic energy potential. Such an arrangement is not so easy to grasp as the other. Optical experiments, however, show us that in all probability it is ρ, and not B, which varies, while from our electrical measurements we know that K is variable and μ constant; hence this is a reason for adopting the second form. In either case we look upon the field as the seat of energy distributed per unit of volume according to Maxwell's law. The total energy is obtained by integration throughout the field. Now we can transform this integral by Green's theorem to a surface integral over the boundary, together with a volume integral through the space; and the form of these integrals shows us that we may look upon the effects, dealing, for the present, with electrostatics only as due to the attractions and repulsions of a certain imaginary matter distributed according to a definite law over the boundary and throughout the space To this imaginary matter, then, in the ordinary theory we give the name of electricity. Thus an electrified conducting sphere, according to these analogies, is not a body charged with a quantity of something we call electricity, but a surface at which there is a discontinuity in the rotation impressed upon the medium, or in the flow across the surface; for in the conductor a viscous resistance to the motion takes the place of rigidity. No permanent strain can be set up

From this standpoint we consider electrical force as one of the manifestations of some action between ether and matter. There are certain means by which we can strain the ether the friction of two dissimilar materials, the chemical action in a cell are two; and when adopting the first analogy, this straining is of such a nature as to produce a rotational twist in the ether, the bodies round are said to be electrified: the energy of the system is that which would arise from the presence over their surfaces of attracting and repelling matter, attracting or repelling according to the inverse square law. We falsely assign this energy to such attractions instead of to the strains and stresses in the ether. Such a theory has many difficulties. It is far from being proved; perhaps I have erred in trespassing on your time with it in this crude form. The words of the French *savant*, quoted by Poincare, will apply to it: "I can understand all Maxwell except what he means by a charged body." It is not, of course, the only hypothesis which might be formed to explain the facts, perhaps not even the most probable. For many points the vortex sponge theory is its superior. Still I feel confident that in time we shall come to see that the phenomena of the electromagnetic field may be represented by some such mechanism as has been outlined, and that confidence must be my excuse for having ventured to call your attention to the subject.

Address to the Mechanical Science Section.

BY JEREMIAH HEAD, M.INST.C.E., PAST-PRES INST MECH.E., F.C.S., PRESIDENT OF THE SECTION.

This section of the British Association for the Advancement of Science was founded with the object of making more widely known and more generally appreciated, all well ascertained facts and well-established principles having special reference to mechanical science. As president of the section for the year, it becomes my duty to inaugurate the proceedings by addressing you upon some portion of the scientific domain to which I have referred, and in which your presence here indicates that you are all more or less interested.

Mechanical Science.

The founders of the British Association no doubt regarded the field of operations which they awarded to Section G as a not less purely scientific one than those which they allotted to the other sections. And, indeed, mechanical science studied, say, by Watt, was as free from suspicion of commercial bias as chemical science studied, say, by Faraday. But whatever may have been the original idea, the practice of the section has recently been to expend most of its available time in the consideration of more or less beneficial applications of mechanical science, rather than of the first principles thereof. Our section has become more and more one of applied rather than of pure science. None of the other sections is free from this fault, if fault it be (which I do not contend or admit), but Section G seems to me to be beyond all question, and beyond all others, the section of applied science.

The charter of the Institution of Civil Engineers commences by reciting that the object of that society is "the general advancement of mechanical science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a civil engineer, being the art of directing the great sources of power in nature for the use and convenience of man" It seems that in 1828, when the institution was incorporated, the term "mechanical science" had a wider meaning than it is now usually understood to have. For, according to the charter, the art of directing the great sources of power in nature is only a particular species of knowledge which "mechanical science" includes. In 1836, or eight years later, the founders of our section adopted the term without again defining it. Probably they accepted the careful definition of the Great George-street Institution Time has shown the wisdom of that decision. For we civil engineers and other frequenters of Section G in active practice need far more knowledge than mechanical science can teach us in the ordinary or narrow sense of the term. Our art in its multifarious branches requires, if success is to be attained, the acquisition and application of almost all the other sciences which belong to the fields of research relegated to the other sections. For how could the gigantic engineering structures of modern times be designed without recourse to mathematics, or steam and other motors without a know

* If we adopted Mr. Heaviside's rational system of units the 4π would disappear.

or modern metallurgical operations be conducted without chemistry, or mining without geology, or communications by rail, ship, and wire be established and carried on with all parts of the world without attention to geography, or extensive manufacturing enterprises be developed if the laws of economics were neglected?" As to biological studies, they seem at first sight to have but little to do with mechanical science. It might even be thought that the civil engineer could afford altogether to neglect this part of the work of the association. But I trust I shall be able to show you before I finish that any such view is absolutely untenable.

Mechanisms in Nature.

Indeed, I hope, in the course of this address, to satisfy you that mechanical science is largely indebted to mechanisms as they exist in nature, if not for its origin, at all events for much of its progress hitherto, and that nature must still be our guide. Mechanical science has been built up entirely upon observation and experiment, and the natural laws which have been induced therefrom by man. The lower animals in their wild condition work with tools or appliances external to their bodies to but a very slight extent, and man in a primitive or savage state does the same. But many, if not most, animals can be taught to use mechanisms if carefully trained from infancy. Thus, the well known donkey at Carisbrooke Castle draws water from a deep well by a treadmill arrangement just as well as a man could do it. He watches the rope on the barrel till the full pail rises above the parapet of the well, then slacks back a little to allow it to be rested thereon, and only then leaves the drum and retreats to his stable. But, according to his attendant, four years were needed for his education, and unless it had been commenced early it would have been useless. I have seen a canary gradually lift from a little well, situated a foot below its perch, a thimble full of water by pulling up with its beak bit by bit, a little chain attached to it, and securing each length lifted with its foot till it could take another pull. When the thimble reached its perch level the bird took a drink and then let it fall back into the well. Numerous other examples will doubtless occur to you. But though animals can be taught to make use of mechanical appliances provided for them—a fact which shows the existence in their brains of a faculty corresponding in kind, if not in degree, to the mechanical faculty in man—they rarely on their own initiative make use of anything external to their bodies as tools, and still more rarely, if ever, do they make, alter, or adapt such mechanical aids. Mr C. Wood, of Middlesbrough, informs me that certain crows which frequent oyster beds on the coast of India wait until the receding tide covers the oysters, which still remain open for a time. A crow will then put a pebble inside one, and, having thus gagged it and secured his own safety, will proceed to pick it out and eat it at leisure. A monkey will crack a nut between two stones and will hurl missiles at his enemies. But in some countries he is systematically entrapped by tying to a tree a hollow gourd containing rice, and having a hole large enough for his hand, but too small for his clenched fist, to pass through. He climbs the tree and grasps the rice and remains there till taken, being too greedy, and not having sufficient sense, to let go the rice and withdraw his hand. This is on a par with the snuff taking imbecile, described by Hugh Miller,* whom the boys used to tease by giving him a little snuff at the bottom of a deep tin box. The imbecile would try to get at it for hours without the idea ever occurring to him that he might achieve his object by turning the box upside down.

All animals are, however, in their bodily frames, and in the intricate processes and functions which go on continuously therein, mechanisms of so elaborate a kind that we can only look and wonder and strive to imitate them a little here and there. The mechanism of their own bodily frames is that with which the lower animals have to be content, and whilst they are in the prime of life and health, and in their natural environment, it is generally sufficient for all their purposes. Man has a still more perfect, or, rather, a still more versatile bodily mechanism, and one which in a limited environment would be equally sufficient for his needs. But he has also an enterprising and powerful mind which impels him to strive after and enables him to enjoy fields of conquest unknown to, and uncared for, by the relatively brainless lower animals. Urged on by these superior mental powers, man must soon have perceived that by the use of instruments he could more quickly and easily gain his ends, and he would not be long in discovering that certain other animals, such as the ox and the horse, were teachable and his willing slaves, provided only he fed and trained them and treated them kindly. First, in common with other animals, he would find out that stones and sticks were of some use as weapons and tools, then he would go further and utilise skins and thongs for clothing and harness; and by selecting and modifying his stones and sticks he would form them into rough implements, which would enable him to cut down trees and to make rude huts and boats. Animals caught and domesticated would first be taught to haul light logs along the ground, then to move heavier ones on rollers; and later, in order to avoid the necessity for continual replacement of the rollers, the wheel and axle would be gradually developed. The mechanical nomenclature of all languages is largely derived from the bodies of men and other animals. From this it is clear that animals have always been recognised as mechanisms, or as closely related thereto. The names borrowed from them generally indicate a resemblance in form rather than in function, though not invariably so. Thus in our own language we have the "head" of a ship, a river, a lake, a jetty, a bolt, a nail, a screw, a rivet, a flight of stairs, and a column of water; the brow of an incline, the crown of an arch; the toe of a pier, the foot of a wall; the forefoot, heel, ribs, waist, knees, skin, nose, and dead eyes of a ship, also turtle-backs and whale backs; the jaws of a vice; the claws of a clutch; the teeth of wheels; necks, shoulders, eyes, nozzles, legs, ears, mouths, lips, cheeks, elbows, feathers, tongues, throats, and arms; caps, bonnets, collars, sleeves, saddles, gussets, paddles, fins, wings, horns, crabs, donkeys, monkeys, and dogs; flywheels, running nooses, crane necks, grasshopper engines, etc.

Not only has our mechanical nomenclature been largely taken from animals, but many of our principal mechanical devices have pre existed in them. Thus, examples of levers of all three orders are to be found in the bodies of animals. The human foot contains instances of the first and second, and the forearm of the third order of lever. The patella, or kneecap, is practically a part of a pulley. There are several hinges and some ball and socket joints, with perfect lubricating arrangements. Lungs are bellows, and the vocal organs comprise every requisite of a perfect musical instrument. The heart is a combination of four force-pumps acting harmoniously together. The wrist, ankle, and spinal vertebræ form universal joints. The eyes may be regarded as double lens cameras, with power to adjust focal length, and able, by their stereoscopic action, to gauge size, solidity, and distance. The nerves form a complete telegraph system with separate up and down lines and a central exchange. The circulation of the blood is a double line system of canals, in which the canal liquid and canal boats move together, making the complete circuit twice a minute, distributing supplies to wherever required, and taking up return loads wherever ready without stopping. It is also a heat distributing apparatus, carrying heat from wherever it is generated or in excess to wherever it is deficient, and establishing a general average, just as engineers endeavour, but with less success, to do in houses and public buildings. The respiratory system may be looked upon as that whereby the internal ventilation of the bodily structure is maintained. For by it oxygen is separated from the air and imparted to the blood for conveyance and use where needed, whilst at the same time the products of combustion are extracted therefrom and discharged into the atmosphere. Mastication, which is the first process in the alimentary system is, or rather should be, a perfect system of cutting up and grinding, and to assist and save animal, and especially human, mastication is the chief aim and object of all the gigantic milling establishments of modern times. The later alimentary processes are rather chemical than mechanical, but still the successive muscular contractions, whereby the contents of the canal are forced through their intricate course, are distinctly mechanical, and may have suggested the action of various mechanisms which are used in the arts to operate on plastic materials, and cause them to flow into new forms and directions.

The superiority of man to the lower animals can only have become conspicuous and decided when he began to use his inventive faculties and to fashion weapons and implements of a more efficient kind than the sticks and stones which they also occasionally use. But human races and individuals were never equally endowed by nature. Some individuals would have greater inventive powers than others, and these and their posterity would gradually become dominant races. Large masses of mankind are still more or less in the position of primeval man, which, if we accept the conclusions of Darwin, Lubbock, and other modern scientists, we must regard as one of barbarism; for they are still without tools, appliances, and clothes, except of the most elementary kinds, and mechanical science might almost be non existent so far as they are concerned.* It would obviously be impossible for me to treat of or call attention even to an infinitesimal extent to the results of mechanical science which surround us now so profusely, and which make our life so different from that of primeval man; and even if it were possible, it would be quite unnecessary. We have all grown up in a mechanical age. We are so familiarised with artificial aids that we have come to regard them as part of our natural environment, and their occasional absence impresses us far more than their habitual presence. I propose, with your leave, to proceed to the consideration of how far man is, in his natural condition, and has become by aid of mechanical science, able to compete successfully with other and specially endowed animals, each in its own sphere of action.

Bodily Powers of Man and other Animals.

The bodily frame of man is adapted for life and movement only on or near to the surface of the earth. Without mechanical aids he can walk for several hours, at a speed which is ordinarily from three to four miles per hour. Under exceptional circumstances he has accomplished over eight miles† in one hour, and an average of 2¾ miles per hour for 141 hours.‡ In running he has covered about 11½ miles in an hour. In water he has proved himself capable of swimming 100 yards at the rate of three miles per hour, and 22 miles at rather over one mile per hour. He can easily climb the most rugged mountain path and descend the same. He can swarm up a bare pole or a rope, and when of suitable physique and trained from infancy can perform those wonderful feats of strength and agility which we are accustomed to expect from acrobats. He has shown himself able to jump as high as 6ft 2¾in from the ground, and over a horizontal distance of 23ft. 3in., and has thrown a cricket ball as far as 382½ft. before it struck the ground.§ The attitude and action of a man in throwing a

* "*My Schools and Schoolmasters*," by Hugh Miller.

* Mr H. L. Lapage, M.I.C.E., who has just returned from Western Australia, states that he found the natives of both sexes and all ages absolutely nude.

† *Whitaker's Almanack*, 1893, p. 395.

‡ Recent pedestrian race from Berlin to Vienna.

§ *Chambers's Encyclopædia*, "Athletic Sports."

stone or a cricket ball, where he exerts a considerable force at several feet from the ground, to which the reaction has to be transmitted and to which he is in no way fastened, are unequalled in any artificial machine. The similar but contrary action of pulling a rope horizontally, as in "tug of war" competitions, is equally remarkable. So also the power of the living human mechanism to withstand widely diverse and excessive strains is altogether unapproachable in artificial constructions. Thus, although fitted for an external atmospheric pressure of about 15lb. per square inch, he has been able, as exemplified by Messrs. Glaisher and Coxwell in 1862, to ascend to a height of seven miles, and breathe air at a pressure of only 3¼lb. per square inch and still live. And on the other hand, divers have been down into water 80ft. deep, entailing an extra pressure of about 35lb. per square inch, and have returned safely. One has even been to a depth of 150ft., but the resulting pressure of 67lb. per square inch cost him his life.[*]

Recent fasting performances (if the published records are to be trusted) are not less remarkable when we are comparing the human body as a piece of mechanism with those of artificial construction. For what artificial motor could continue its functions 40 days and nights without fuel, or, if the material of which it was constructed were gradually consumed to maintain the flow of energy, could afterwards build itself up again to its original substance? These and other performances are, when considered individually and separately, often largely exceeded by other animals specially adapted to their own limited spheres of activity. The marvel is not, therefore, that the human bodily mechanism is capable of any one kind of action, but that, in its various developments, it can do all or any of them, and also carry a mind endowed with far wider powers than any other animal.

Animals other than man are also adapted for life and movement on or about the surface of the earth. This includes a certain distance below the ground, as in the case of earthworms; under the water, as in the case of fish; on the water, as in the case of swimming birds; and in the air as with flying birds. As far as I know, no animal burrows downwards into the earth to a greater depth than 8ft.,[†] and then only in dry ground. Man is naturally very ill adapted for boring into the earth as the earthworm does. Indeed, without mechanical aids he would be helpless in excavating or in dealing with the accumulations of water which are commonly met with underground. But by aid of the steam engine for pumping, for air compressing, ventilating, hauling, rock boring, electric lighting, and so forth, and by the utilisation of explosives, he has obtained a complete mastery over the crust of the earth and its mineral contents down to the depth where, owing to the increase of temperature, the conditions of existence become difficult to maintain. I have said that on land man, unaided by mechanism, has been able to cover about 11½ miles in one hour. Two miles he has been able to run at the rate of nearly 13 miles per hour, and 100 yards at the rate of over 20 miles per hour.[‡] But the horse, though he cannot walk faster than man, nor exceed him in jumping heights or distances, can certainly beat him altogether when galloping or trotting. A mile has been galloped in 103 seconds, equal to 35 miles per hour, and has been trotted in 124 seconds, equal to 29 miles per hour.[§] There are many other animals, such as ostriches, greyhounds, antelopes, and wolves, which run at great speeds, but reliable records are difficult to obtain, and are scarcely necessary for our present purpose.

Mechanical Aid without Extraneous Motive Power.

Let us now consider how man's position as a competitor with other animals in speed is affected by his use of mechanical aids, but without any extraneous motive power.

Locomotion on Land.—Where there is a stretch of good ice, and he is able to bind skates on his feet, he can thereby largely augment his running speed. This was exemplified by the winner of the match for amateurs at Haarlem last winter, who accomplished the distance of 3·1 miles at the rate of about 21 miles per hour. But the most wonderful increase to the locomotive power of man on land is obtained by the use of the modern cycle. Cycling is easily performed only where roads, wind, and weather are favourable. But similar conditions must also be present to secure the best speed of horses, with which we have been making comparison. One mile has been cycled at the rate of 27·1 miles per hour, 50 at 20,[¶] 100 at 16·6,[¶] 388 at 12·5,[**] and 900 at 12·43 miles per hour. The recent race between German and Austrian cavalry officers on the high road between Vienna and Berlin has afforded an excellent opportunity to judge of the speed and endurance of horses as compared with men over long distances. Count Starhemberg, the winner, performed the distance, about 388 miles, in 71·33 hours, equal to 5·45 miles per hour. He rested only one hour in twelve. His horse, though successful, has since died.[††] Lawrence Fletcher cycled, also along the high roads, from Land's End to John o' Groats' house, 900 miles, in 72·4 hours, equal to 12·43 miles per hour, or more than double the distance that the Count rode, and at above double the speed. To the best of my knowledge he still lives, and is no worse for his effort. The horse in this case would have to carry extra weight equal to one-sixth of his own, and the cyclist equal to a quarter of his own. But the horse carried himself and his rider on his own legs, while the cyclist made his machine bear the weight of itself and rider. Herein was probably the secret of his easy victory. With the very remarkable exception of long-distance cycling, which is of limited application, man relying on his own bodily strength cannot successfully compete with other animals which, like the horse, are specially fitted for rapid land locomotion. His only alternatives are either to utilise the horse and ride or drive him, and so get the benefit of his superior strength and speed, or to use his own inventive faculty and construct appliances altogether apart from animal mechanism. In either case he virtually gives up the contest as a self-moving animal, and to a great extent abandons himself to be carried by others or by inanimate machinery. Nearly 70 years ago mankind came to this conclusion, and the modern railway system is the result. The locomotive will go at least double the speed of the racehorse. It will carry, not only itself, but three or four times its own weight in addition, but will go not two or three, but 100 miles or more without stopping, if only the road ahead be clear. And the iron horse is fed and controlled without even so much exertion as that put forth by a man on a horse of flesh and bone.

Locomotion on Water.—Let us now consider the powers of man relatively to other animals in moving upon and through the great waters with which three-fourths of the earth's surface is covered. Here he is in competition with fishes, aquatic mammals, and swimming birds. I have already stated that, unaided by mechanism, he has shown himself able to swim, for short distances at the rate of three and long distances (22 miles) at the rate of one mile per hour. He has also given instances of being able to remain under water for 4½ minutes.[*] Credible eye witnesses inform me that porpoises easily overtake and keep pace with a steamer going 12½ knots, or, say, over 14 miles per hour, for an indefinite length of time. This is five and fifteen times the maximum swimming speed of a man for short and long distances respectively. No doubt the form and surface of a fish whose main business is swimming offer less resistance, and his muscular power is more concentrated and better applied towards propulsion in water than is the case with man, whose body is also adapted for so many other purposes. I am further informed by Mr. Nelson, of Redcar, a naturalist who has made the experiment, that it is impossible for an ordinary sea boat, rowed by two men and going at five miles per hour, to overtake the aquatic bird called the Great Northern Diver, when endeavouring to make his escape by alternately swimming on the surface and diving below. His speed is therefore nearly double the short and five times the long distance speed of unaided man in water. As regards remaining under water, fishes properly so called have unlimited powers, and even aquatic mammals, such as whales, can remain under for 1½ hours. Using only his own strength, but assisting himself with mechanical devices, man has been able to increase considerably his speed as a swimming animal. Mr. John McCall, of Walthamstow, informs me that in 1868 he constructed and repeatedly used an apparatus which acted like the tail of a fish. It consisted of a piece of whalebone, having a broad yet thin and elastic blade tapering into a shank like the end of an oar. The blade was 15in. wide and 4ft. long, including the shank. To the end of the latter a horizontal cross bar, 15in. long, was fitted, and leather pockets were provided at the ends for the feet. By swimming on his back and striking out alternately with his legs, he was able, with the assistance of this apparatus, to keep up with a sea boat pulled by two men at about four miles per hour. By means of boats, which he propels by oars or sculls, and notwithstanding the increased weight, and therefore displacement, involved by them, man has been able to increase his speed on the surface of the water to a maximum of about 12 miles per hour for about four miles distance, under favourable circumstances. So, by supplementing his bodily powers by means of mechanical aids, such as the diving bell and the diving helmet, dress, and air pump, or by the portable self-acting apparatus used with such good effect in the construction of the Severn tunnel, man has been able to approach very nearly to the natural diving powers of, at all events, aquatic animals, except that he cannot move about in subaqueous regions with anything approaching their ease and celerity. Invariably, on water, as almost invariably on land, man is quite unable to compete in power of locomotion with other specially adapted animals, whether or not he avails himself of mechanical aids, so long as his own bodily strength is the only motive power he employs. He has gradually come to recognise this fact, and to see that he must use his inventive faculties, and find new and powerful motors external to himself if he would really claim to dominate the great waters of the earth. The fastest mechanism of any size, animal or man made, which, as far as I know, has ever cut its way through the waters for any considerable distance, is the torpedo boat "Ariete," made by Messrs. Thornycroft and Son, of London, in 1887. It has a displacement or total weight of about 110 tons, and machinery capable of exerting 1,290 effective horse-power, or 11·7 h.p. per ton of weight or displacement; or, to put it in another form, an effective horse-power is by it obtained from a weight of 191lb., which includes vessel, machinery, fuel, stores, and attendants. The speed accomplished at the trials of this little craft, being the average of six one-mile tests, was 26·18 knots, or 30·16 miles per hour.[†] As might be expected, it resembles a fish, in that its interior is almost exclusively devoted to the machinery and accessories necessary for propulsion. During the trials the water, fuel, stores, and other ponderable substances carried amounted to 17·35 tons. Two similar boats were able to make the voyage to South America by themselves, though at much slower speed and replenishing their fuel on the way. No fish or swimming bird can

[*] *Pall Mall Gazette*, July 5, 1893, p. 8.
[†] "Vegetable Mould and Earthworms," by Charles Darwin, p. 111.
[‡] *Chambers's Encyclopædia*, "Athletic Sports."
[§] *Ibid.*, "Horse."
Whitaker's Almanack, 1893.
[¶] *Times*, September 26 to October 7, 1892.
[**] *Chambers's Encyclopædia*, "Cycling."
[††] Vienna Berlin Race, June, 1893.

[*] *Whitaker's Almanack*, 1893.
[†] *Engineering*, July 15, 1887.

match this performance. And inasmuch as 191lb. of dead weight produced 1 h.p., as compared with from 150lb. to 250lb. in certain flying birds, it would seem that with suitable adaptations the "Ariete" might even have been made to navigate the air instead of the water.* But I will revert to this subject later on. Where safety in any weather, and passenger and cargo-carrying powers are aimed at, as well as, or prior to, the utmost attainable speed—and these must ever be the leading features of ocean transit steamers if they are to attain commercial success—there I must refer you to those magnificent examples of naval architecture which are more or less familiar to you all, and of which we, as a maritime nation, are so justly proud. If for example, we turn our attention for a moment to the new Cunard liners, the "Campania" and "Lucania," having each a weight or displacement of 18,000 tons and 24,000 effective horse power, or 1.33 h.p. per ton of displacement, we shall find that with the commercial advantages alluded to they obtain a maximum speed of 22.5 knots, or about 26 miles per hour. If, instead of 1.33 effective horse power per ton of displacement, they were provided with eight times that amount, or 10.64 h.p. per ton, thereby sacrificing passenger and cargo accommodation and making them nearly as full of propelling machinery as the "Ariete" torpedo boat, and if it were then found possible to apply this enormous power effectively, then there is every reason to believe they would accomplish for short distances double the speed, or say, 45 knots, or about 52 statute miles, per hour. By inventing and utilising mechanical contrivances entirely independent of his own bodily strength, man can now pass over the surface of the waters at the rate of over 500 knots per day, and at the same time retain the comforts and conveniences of life as though he were on shore. He has in this way beaten the natural and specially fitted denizens of the deep in their own element as regards speed and continuity of effort. But he is still behind them as to safety. We do not find that fishes or aquatic mammals often perish in numbers, as man does, by collisions in fogs, or by being cast on lee shores and rocks by stress of weather. Shall we ever arrive at the point of making ocean travelling absolutely safe? The Cunard Company is able to boast that from its commencement, 53 years ago, it has never lost a passenger's life or a letter, a statement which gives ground for hope that almost absolute safety is attainable. But, on the other hand, other owners of almost equal repute (not excluding the British Admiralty) are ever and anon losing magnificent vessels on rocks, in collisions, by fire, and even by stress of weather, in a way which makes us doubt whether it is possible for Britannia, or anyone else, really to "rule the waves." In one way the chances of serious disaster have been of late largely diminished, and here, again, nature has been our teacher. The bodies of all animals, except the very lowest, are symmetrically formed on either side of a central longitudinal plane. Each important limb is in duplicate, and if one side is wounded the other can still act. We have at last found out the enormous advantage and increased safety of having the whole of our ship-propelling machinery in duplicate, and our ships made almost unsinkable by one longitudinal and numerous transverse bulkheads.

Locomotion in Air.—I now come to consider what is the position of man as regards locomotion in and through the great atmospheric envelope which surrounds the earth in comparison with animals specially fitted by Nature for such work. Nature seems never to bestow all her gifts on one individual or class of animals, and she never leaves any entirely destitute. For instance, the serpent, having no limbs whatever, would seem at first sight to be terribly handicapped; yet, in the language of the late Prof. Owen, "it can out-climb the monkey, out-swim the fish, out-leap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the air and seize the bird on the wing."† Here we have the spiral spring in nature before it was devised by man. Flying animals seem to conform remarkably to this law. Thus we have birds, like the penguin, which dive and swim, but cannot fly; others, like the gannet, which dive, swim, fly, and walk; others, like the ostrich, which run, but can neither fly nor swim; and numberless kinds which can fly well, but have only slight pedestrian powers. Man, unaided by mechanisms, can, as we have seen, walk, run, swim, dive, and jump, and perform many remarkable feats; but for flying in the air he is absolutely unfitted. All his attempts (and there have been many) have up to the present been unsuccessful, whether or not he has availed himself of mechanical aids to his own bodily powers. It is said that a certain man fitted himself with apparatus in the time of James VI. of Scotland, and actually precipitated himself from the cliff below Stirling Castle, in sight of the king and his courtiers; but the apparatus collapsed, and he broke his leg, and that was the end of the experiment. But why should not man fly? It is not that he does not desire to do so. For every denizen of our precarious British climate, when he has noticed the ease with which swallows and other migratory birds fly off on the approach of winter, hundreds and even thousands of miles to the sunny south, must have wished he could do the same. One reason why we cannot fly, even with artificial aids, such as wings, is that, as in the case of the penguin or the ostrich, our bodily mechanism is specialised and our muscular power diffused in other directions, so that we could not actuate wings of sufficient area to carry us even if we had them. M. de Lucy, a French naturalist, has shown that the wing-area of flying animals varies from about 49 square feet per pound of weight in the gnat, and five square feet in the swallow, to half a square foot per pound of weight in the Australian crane, which weighs 21lb., and yet flies well. If he were to adopt the last or smallest proportion, a man weighing 12 stone would require a pair of wings each of them 14ft. long by 3ft. broad, or double the area of an ordinary room door, to carry him, without taking into account the weight of the wings themselves. In flying birds there is a strong tripod arrangement to secure firm points of attachment for the wings, and a deep keel in the breast bone, to which the large pectoral muscles are secured. Think of the wings I have described and the absence of pivots, keel, and muscles in man, and it will be tolerably obvious why he cannot fly, even with artificial wings. But it might be contended that a man's strength is in his legs rather than in his arms, and that it is conceivable that a successful flying apparatus might be made if adapted for the most, instead of the least, favourable application of his bodily strength. According to D. K. Clark,* a labourer working all day exerts on an average .13 h.p. The maximum power of a very strong man for a very short time is .46 h.p. According to Dr. Haughton,† the oarsmen in a boatrace of one mile, rowed in seven minutes, exerted each .26 h.p. Suppose we take the rowing case as the maximum maintainable for, say, seven minutes, by a man weighing 168lb. Then in flight he would have to sustain a weight of

$$\frac{168}{.26}=646\text{lb.}$$

per horse power exerted, besides the weight of the apparatus.

Now, we shall find later that no birds support even half that weight per horse power which they have the power to exert, and that recent aeroplane experiments prove its impossibility. On the ground, therefore, that he is too heavy in proportion to his strength, it is clear that man is unfitted for flight, as well as because his limbs are not adapted for it. It does not follow, however, that by aid of mechanisms apart from his own body, and worked by power independent of his own strength, man may not imitate, compete with, and even outdo the fowls of the air. Let us consider a few facts showing what birds can do. A gannet hovers in the air above the sea. Suddenly he nearly closes his wings, swoops down, and with a splash disappears below the surface. Shortly after he reappears with a fish in his mouth, which he swallows in a few gulps; then, after swimming on the surface a little, he reascends into the air to repeat the operation. The swallow rises into the air with a few rapid movements of the wings, then slides down as though on an aerial switchback, and then up again till he nearly reaches his original height, or he circles round by raising one wing, like a runner rounding a curve. The condor vulture, which measures sometimes 15ft. across the wings, will fly upwards till quite out of sight. A flock of cranes have been seen migrating at a height of three miles, and proceeding apparently without any movement of the wings. The peregrine falcon will swoop down upon a partridge, and, missing it by a doubling movement of the latter, will slide upwards, thus converting his kinetic into new potential energy. He will then turn and descend again, this time securing his prey. Mr. J. E. Harting, one of the principal British ornithological authorities, has, after careful investigation, arrived at the conclusion that the speed of falcons in full flight is about 60 miles per hour.‡ Mr. W. B. Tegetmeier, another well-known authority, gives the results of a number of experiments on the speed of homing pigeons, made under the auspices of the United Counties Flying Club in 1883. The average speed of the winner in 18 races was 36 miles, and the maximum 55 miles per hour. The greatest distance flown was 309 miles. The albatross, the largest web-footed bird, measuring sometimes 17ft. from tip to tip of wing, and weighing up to 20lb., frequently accompanies ocean steamers from the Cape to Melbourne, a distance of 5,500 knots, without being seen to rest on the way. An American naturalist, Mr. J. Lancaster, who spent no less than five years on the west coast of Florida, in order to study the habits of aquatic and other birds which frequent those shores, arrived at the following conclusions, viz.:§ Though all birds move their wings sometimes, many can remain indefinitely in the air, with wings extended and motionless, and either with or without forward movement. This he calls "soaring." The wing area of soaring birds varies from one to above two square feet per pound of weight. The larger the wings per pound of weight, the greater the power to soar. The heavier the bird, the steadier his movements. Soaring birds always face the wind, which, if they do not move forward or downward, must not blow at a less speed than two to five miles per hour. Mr. Lancaster specially watched a flock of buzzards about 30ft. above his head, waiting for him to leave the body of a dead porpoise. Their wings were about 5ft. from tip to tip, and their average weight about 6lb. During three hours at midday, when the wind which they faced was very strong, they flapped their wings about 20 times each. Later, during two hours, when the wind had subsided, they never moved them at all. Mr. Lancaster timed frigate birds, and found them able to go at the rate of 100 miles per hour, and that on fixed wings; he is of opinion that at all events up to that speed they can fly just as fast as they please. He says further that the same birds can live in the air a week at a time, night and day, without touching a roost, and that buzzards, cranes, and gannets can do the same for several hours at a time. The observed facts relating to the phenomena of flight

* M. Normand, of Havre, is building for the French Government two torpedo boats, each having a displacement of 125 tons and 2,717 effective horse power, or 21.7 h.p. per ton of displacement. This is equivalent to 1 h.p. per 103lb., and is still within the limits of weight permissible for aerial flight.—See *Times*, *June 10, 1893.*

† *Pettigrew on "Animal Locomotion."*

* "Rules, Tables, and Data," pp. 719 and 720, by D. K. Clark.

† "Animal Mechanics," by Dr. Haughton.

‡ *Field*, December 5, 1891, p. 858.

§ "Problem of the Soaring Bird," *American Naturalist*, 1885, pp. 1,055-1,162.

‖ *Field*, January 22, 1887, p. 114.

are still but very imperfectly understood. That a bird should be able to maintain a downward pressure on the air sufficient to counteract the effect of its own weight, and a backward pressure sufficient to force itself forward at such speeds as I have named, seems wonderful enough when it is known that it continuously operates its wings; but that it should be able to do the same without any muscular movement at all is almost incomprehensible. It seems to be an instance of the suspension of the laws of gravity and of the existence of cause without effect, and of effect without cause. It is not a case of flotation like a balloon, for any bird falls to the earth like a stone when shot. Mr Lancaster suggests that the bird's own weight is the force which enables him to counteract the effect thereof, but this explanation is, I confess, beyond my comprehension. It seems to me that for every pound of his weight pressing downwards there must be an equivalent force pressing upwards. This can be produced only by his giving downward motion to the air previously at rest, or by his arresting previous motion of air in an upward direction. The latter alternative involves the supposition that the air currents which soaring birds face are not, as Mr. Lancaster believes, always horizontal, but must have, to some extent, an upward direction. If a parachute were falling in a current of air which was moving upwards at the same rate as the parachute fell, it would obviously retain its level, yet gravity would be acting. So, if a bird with extended wings were sliding down a stream of air which was tending upwards at the same angle and same velocity, the phenomenon of soaring would be produced.

(To be continued.)

BUSINESS NOTES.

Commercial Cable Company.—A quarterly dividend of 1¼ per cent. is announced, payable on the 2nd prox.

Western and Brazilian Telegraph Company.—The receipts for the week ended September 8 were £1,919.

Bowness.—The surveyor, in his monthly report to the Local Board, states that all the street lamps are now supplied with the electric light.

The British Association. The Town Council of Ipswich have resolved to invite the British Association to hold its meeting for 1895 at Ipswich.

Wolverhampton.—The Town Council have received formal sanction to borrow £1,928 for the purchase of land for the purposes of electric lighting.

Taunton.—The Taunton Corporation are now prepared to receive applications for electric lighting, and they will be ready to supply electricity after the 30th inst.

Stonehouse.—Mr. Bone suggested, at a meeting of the Local Board on Tuesday, that as they were going to light the Town Hall by electricity, the lamp at the entrance should be similarly illuminated.

Appointment.—It is stated that one of the electricians trained under Mr. W. Chew, M.I.E.E., at the old Blackpool Corporation Electricity Works, has been offered a post of electrical engineer to an installation in a Lancashire town.

Resignation.—We are informed that Mr. R. Turnbull has resigned his position with the New Zealand Electrical Syndicate, Limited, and the Gulcher Company, and that his address in future will be Custom House Quay, Wellington, New Zealand.

Worcester. The Highways and Bridges Committee of the Worcester County Council have granted the application made by the Corporation of Worcester for permission to break up the Malvern and Worcester road for the laying of electric light mains.

Zambesia.—A contract was to be signed yesterday between the Portuguese Government and the Zambesi Company for the laying of a submarine cable to establish telegraphic communication with Zambesia, and for the construction of land telegraph lines in that region.

Winchcombe.—The ratepayers have voted that the lighting inspectors should make a trial of oil illumination for the streets instead of gas, about which some dispute has arisen with the gas company. Electric lighting does not appear to have been considered.

Bangor.—At a meeting of the City Council last week, the accountant reported that the estimated cost of painting parts of the reading room and fixing electric communication between the reading room and house, etc., would be about £12. It was resolved that the work be done.

Bradford.—The Corporation are inviting tenders, to be sent in by Tuesday next, for the supply of switchboards. Plans and specifications may be seen at the office of the electrical engineer at the Town Hall, Bradford, or copies may be obtained on payment of one guinea.

City and South London Railway Company. The receipts for the week ending September 10 were £751, against £768 for the same period last year, or a decrease of £17. The total receipts for the second half year of 1893 show an increase of £429 over those for the corresponding period of 1892.

Tenders for Cables.—The Secretary of State for Foreign Affairs has received from her Majesty's Ambassador at Madrid a copy of a Spanish Royal Order, setting forth the conditions for the construction and laying of submarine telegraph cables uniting the islands of Luzon and Las Visayas, tenders for which are invited. The order can be seen on personal application at the Commercial Department of the Foreign Office between the hours of 11 and 6 daily.

Burnley.—It was suggested by Councillor Harker at a meeting last week of the Town Council, that the two arc lamps in the centre of the town should be placed higher. Alderman Lancaster said they had not decided to light all the streets with electricity, but to supply it to the tradesmen, but Councillor Altham thought that the Council could surely see their way to placing arc lamps at the principal points in the centre of the town.

Portsmouth. The Electric Lighting Committee of the Town Council submitted on the 5th inst. certificates from Messrs. Waller and Manville for payment to the contractor for the erection of the electric lighting station in Gunwharf-road of the sum of £500, and to the contractors for the boilers, engines, and electrical plant of the sum of £2,500 on account of the work executed, and recommended that such amounts be paid. This was agreed to.

Bolton. A special meeting of the Bolton Town Council was held on Wednesday to approve of the proceedings of the Gas and Lighting Committee, which has let contracts in connection with an extensive scheme of electric lighting which the Corporation are about to embark upon. Borrowing powers to the extent of £40,000 have been applied for to the Local Government Board, and an extensive system of mains will very shortly be laid in the principal thoroughfares.

Bath. When the Surveying Committee of the Town Council met last week, Mr. Sturges mentioned, in reply to a question raised by Mr. Taylor at the previous meeting, that the testing of the electric light for the public lamps by Mr. Gatehouse was carried out at the works; for private lighting the testing was done at his own office. He mentioned that the men at the works were determined to get more pay, and in consequence the company could not get the men to attend to their duty quite as well as they wished they could. However, that trouble was over now.

Telegraph Accounts. An estimate of the revenue and expenditure of the Post Office Telegraphs for the year ending March 31, 1893, has been issued from the Treasury as a parliamentary paper. The total revenue is estimated at £2,528,423 and the total expenditure at £2,683,789. The percentage of total expenditure to total revenue is 106.14, and there is estimated a deficit in the net revenue of £155,366. The percentage of salaries, etc., to total revenue is 67.95. The estimated cost of telegraphic extension is £96,989, the actual cost for the year 1891-92 having been £156,383.

Dorman and Smith.—Owing to the increasing demands for their manufactures, and recognising the desirability of personally consulting their friends both in London and the provinces as to particulars of their requirements, Messrs. Dorman and Smith, on the termination of their agreement with Mr. H. R. Wood, have placed this department under the control of Mr. A. H. Dorman. Although occupying the present London offices, Mr. Dorman will make periodical visits to the chief centres of the electrical industry, and also be in constant communication with their head office and works in Manchester.

Blackburn. The Town Council on the 7th inst. adopted the following minutes of the Gas Committee: "That in the event of the Town Council authorising this committee to proceed with the extension of the gasworks, a portion of the No. 1 gasworks be used as a temporary site for the electric lighting installation, and that it be an instruction to the town clerk to issue advertisements in accordance with the plans and specifications which have been approved by this committee for the necessary electric lighting machinery; the necessary building and alteration of the gasworks to be carried out by the Corporation's own workmen."

Harrogate. At the quarterly meeting on Monday of the Town Council the sub-committee reported that they had conferred with Mr. Wilkinson with reference to his appointment as electrical engineer to the Corporation, and had agreed with him as to terms on which he should prepare and carry out the installation in accordance with his report previously made. It was decided to approve the report of the sub-committee, and to enter into an agreement with Mr. Wilkinson accordingly, the design and construction of the necessary building to be carried out by the borough surveyor, and the works of the engineering department by Mr. Wilkinson.

Scarborough.—At a meeting of the special sub-committee of the Town Council as to the proposed telegraph wire to the South Cliff Post Office, the town clerk had submitted a draft of a proposed letter to the Postmaster-General calling his attention to the injurious effect which the proposed line of telegraph would have upon the houses adjoining the back streets if the telegraph wires were carried overhead, and suggesting that the matter had better be referred to the county court judge, as provided by the Telegraph Act, 1878. It was resolved that the letter as drafted be forwarded to the Postmaster-General and this recommendation has been adopted by the Town Council.

Cardiff.—Alderman Carey read on Monday, at a meeting of the County Council, a letter which had appeared in the *Times* protesting against the agreement about to be entered into between the Post Office authorities and the National Telephone Company, which, it was alleged, would prove injurious to the public in years to come. He pointed out that Manchester, Liverpool, and other large centres had consulted the members of Parliament in the matter, and seeing that it affected them in the matter of tearing up their streets and roads, he moved that the town clerk should communicate with other municipalities with a view to their taking common action in the matter. A resolution to this effect was adopted.

International Electric Syndicate.—This Company was formed in April, 1891, to acquire patents and improvements in the construction of accumulators, and generally to carry on the business

of electrical machinery manufacturers. The nominal capital was £12,000, divided into £10 shares, but only 807 were allotted, and of that number 800 were issued to the vendors as fully paid. No statement of affairs has yet been filed, because, it is said, the only officers of the company who appear to be able to file the same have left the country. Meetings of creditors and shareholders were held on Wednesday, and the company was left in the hands of the official receiver to be wound up in the usual manner.

Lincoln.—The Town Council on the 7th inst. considered a notice from the London and Brush Provincial Electric Lighting Company, Limited, stating their intention to apply to the Board of Trade for a provisional order to authorise the supply of electricity within the city of Lincoln and certain adjacent parishes, and a letter from Messrs. Andrew and Trotter asking the Corporation to consent to the application. It was decided to refuse the request inasmuch as the Corporation themselves possess special facilities for lighting the city with electricity, and are quite prepared to undertake the work as soon as they are satisfied that the true interests and advantages of the inhabitants demand the supply of such a mode of lighting in the city and adjacent parishes.

Halifax.—A meeting of the Halifax Town Council in committee was held on Tuesday. A question having arisen through the proposal of a company to lay an overhead electric trolley system, with the permission of the authorities, Councillor H. E. Greenwood moved that the question be adjourned *sine die*. Councillor Maude seconded the motion. Alderman Tattersall submitted an amendment to the effect that in the opinion of the Council the construction of an efficient tramway system was desirable as soon as the finances of the borough would admit of one being laid, but it should be under the control of the Corporation. Councillor Lister seconded this. The amendment was lost by a large majority, only five voting for it. The original proposition was then carried unanimously.

Lighting at Blackpool.—The questions of electric lighting and gas and tramways were discussed last week by the Town Council. It was anticipated that the arc lighting would be ready before October. Mr. Councillor Pearson said that if they could make a good display, amounting to an illumination worthy of thousands of visitors coming down to see it, it would be worthy of the effort. The pillars were fixed in position, the lamps were going through some tests, and it was intended that they should be perfect before being fixed on the promenade. Mr. Alderman Parkinson, in moving the adoption of the minutes of the Markets and Gas Committee, said that the members of the committee felt that there was room for electricity and gas, and they hoped that electricity would prove a success. They did not think the demand for gas had reached the maximum yet.

Montrose.—A report from Mr. Wm. A. Bryson, electrical engineer, Glasgow, in reference to the suggestion that the electric light should be introduced into Montrose was read at a meeting of the Town Council on Monday. In the course of his report, Mr. Bryson stated that he was of opinion that it would be neither satisfactory nor economical to adopt water as the motive power. He therefore suggested the laying down of a small central lighting station with steam engines and boilers, or preferably gas engines and producers, the total cost of which he estimated would be £6,000, or if a large battery of accumulators was added the cost would be increased to £8,000. Details were also given as to the annual cost of maintenance, and Mr. Bryson works out a credit balance to the town of £352, and the price he estimates at 6d. per unit, equivalent to gas at 5s. per 1,000ft. It was agreed to let the report lie over until a future meeting.

Dawlish.—The Local Board, at a meeting last week, had under consideration a letter from Messrs. Rose and Co., of Manchester, stating that they had noticed that the Board had resolved to erect a fire alarm in the town, and offering to provide a double bell with fittings for £11. 15s. The National Telephone Company wrote offering to fix and maintain six electric bells at the addresses pointed out by the committee for the sum of £5 per annum for five years; otherwise, they would erect and maintain four electric bells and three telephones for the sum of £6 per annum for five years. Mr. H. James, of St. Thomas, Exeter, wrote offering to fit electric fire bells in the houses of 11 members of the fire brigade, the bells to be rung from any suitable place that may be decided on. He would also fix all necessary wires, bells, etc., and maintain same in a working order for the sum of £6. 15s. Or he would fix bells to six of the nearest firemen to the call station and maintain same at an annual rental of £3. These prices would include the use of a street fire alarm. Mr. Bayldon proposed that Mr. James's offer be accepted. Mr. Hearn supported, and the motion was carried.

Lighting at Blackburn.—We are informed that the Wray Electrical Engineering Company, of Soho Works, Thornton road, Bradford, have secured the contract for the erection of a complete electric light plant at the extensive cotton mills of Messrs. E. Heyworth and Sons, Audley Hall Mills, Blackburn. The installation will consist of about 750 lamps of 16 c.p., with separate slow speed vertical engine, supplied by Messrs. Robey and Co., of Lincoln, and specially designed for this installation in combination with a direct-driven dynamo. The firm are also engaged on the wiring and fitting up of the Mersey Rice and Flour Mill, Liverpool, owned by Mr. Edward Hutchinson. This will be one of the largest electric light installations in corn mills in the North, and will consist of two 400-light dynamos and storage for 400 lights, together with a separate engine and dynamo for lighting the mill in the daytime. The Wray Electrical Engineering Company have recently completed a similar installation at Messrs. H. Leetham and Sons, Hungate Flour Mills, York. The company are very busy, being engaged on the following installations: Messrs. Pattinson and Winter, corn millers, Whitehaven; Messrs. Nicholson and Birkett, Kirton Lindsey, Gainsborough; Messrs. Goodall's Drug Company, Morley; Messrs. Robinson Bros., Town Corn Mills, Rotherham; and Messrs. J. Wigfull and Sons, Star Corn Mills, Sheffield.

Lighting at Morley.—We give the following information supplementary to that published in our last issue. The Electric Lighting Committee of the Town Council resolved on August 10 that schemes should be invited to be submitted for the electric lighting of the Town Hall and the borough generally, separately, and to pay £100 to the successful competitor. Alderman Schofield, in moving the adoption of the committee's resolution at a meeting of the Town Council last week, said the committee had taken no definite action. Councillor Rhodes seconded the motion. Alderman Dixon thought that spending £100 in that way was a waste of money. If they advertised for competitors to offer schemes, he believed they would get 50 people who would be willing to give them their advice and show them schemes that would be equally as good as those they offered to pay for. He found no other towns in England where they talked about having the electric light giving £100 for a scheme. He was not opposed to the electric light—it might be advantageously applied; but to give £100 for a scheme was monstrous. He proposed an amendment that the minutes be confirmed with the exception of the giving of a premium of £100 to the successful competitor. Alderman Rhodes seconded the amendment, and said there were parties who would be glad to supply all the information they required without being paid for it. On being put to the meeting, the amendment was lost and the minutes confirmed in their entirety.

Edinburgh.—On Monday evening a number of prominent citizens joined the magistrates and Council of Edinburgh in an inspection of the new refuse disposal works at Powderhall. The destructor has now been in operation for some three or four weeks, and the results, it appears, have been in every way satisfactory. With the aid of the electric light, with which the works are fitted, the company had an excellent opportunity of seeing what could be done in the disposal of city refuse by artificial means. At the close of the inspection, Lord Provost Russel delivered a short address. He recalled both the circumstances which led up to the erection of the works—the main difficulty felt by the authorities being that of getting rid latterly of the town refuse—and the character of the opposition originally entertained towards the destructor. Eventually, however, the Corporation saw that the problem had to be solved, and that had been done largely owing to the exertions of Councillor Sloan. His lordship pointed generally to the facilities now afforded for the disposal of refuse, and touched on the question of the utilisation of the surplus power in providing electric light in the immediate neighbourhood of the works. This, however, was a matter that might be further considered when the destructor scheme was further developed, as it would no doubt have to be by and by. Councillor Sloan suggested that the surplus power might be used in supplying electric light to public baths and washhouses in the neighbourhood of a destructor, or in forming an installation for other public purposes.

Electric Lighting in Dundee.—At a meeting of the Lighting Committee of the Dundee Police Commission on the 5th inst., the minute of the sub-committee of the Lighting Committee concerning the lighting of the streets by electricity was submitted. It recommended the erection of the following lamp standards: In Nethergate, 10; Murraygate, five; Reform street, four; Commercial-street, eight; Castle street, three; Whitehall street, three; and Union street, three; in all, 36. The convener explained that in these thoroughfares 123 gas lamps could be dispensed with. He also reported that the expense of erecting the lamps and lighting the thoroughfares mentioned would be, for supplying and erecting 36 lamp standards, £550, supplying light thereto at £20 each, £720. Deducting from this 123 gas lamps at £1. 12s. 6d. each, amounting in the aggregate to £200, there was a balance left of £1,070. He further recommended that the first cost of the lamp standards and their erection should be spread over a period of three years, thus making an annual charge against the scheme for the first three years as follows: One third cost of supplying and erecting lamp standards, £183. 6s. 8d.; expense of supplying light, £720; total £903. 6s. 8d. After taking from that 123 gas lamps, equal to £200, they were left with £703 as the expenditure for the first three years for supplying lamp standards and lighting. The sub-committee recommended that the Commissioners erect the lamps provided the Gas Commissioners supply light at a rate of £20 each. The minute was approved of, and it was remitted to the sub-committee to carry the arrangements into effect. They also resolved to include an addition of 14 lamps to the east and west stations.

Lighting at Glasgow.—Mr. Mitchell, moving the approval of the accounts of the Gas Trust at a meeting of the Town Council last week, referred to the year's operations of the Gas and Electric Lighting Committee. In the electrical department the committee were able to see progress and reasonable prosperity, for a small loss of £1,773 on the first year's operations of such a concern, and the explanations in the report, seemed to point to success at no distant date. The Waterloo street works were now practically fully occupied, and two additional engines and dynamos had been ordered to meet the extra enquiries for the coming winter, so that with steadily increasing business they might hope the electric lighting department would soon be profitable, and advantageous alike to suppliers and consumers in future years. In conclusion, the Gas and Electric Lighting Committee proposed formally to ask the Council to fix the price of gas at 2s. 6d. per 1,000 cubic feet from date of last survey, being a reduction of 3d. from last

year's price, and to continue the price of electric current at 7d per unit, the same as last year. In doing so they wished to express their sense of the valuable work done by the engineer, Mr Foulis, and the works managers; Mr. Fleming, treasurer; Mr. Arnot, electrical engineer, and all other officials, to whom much of this favourable result was due. It might be that in years to come the light of the future might become the light of the present, and the coalmaster and gas lighting things of the past; but however that might be, the committee trusted the Council would ever interest themselves deeply in this great manufacturing department, to which they devoted much time and attention, and in whose continued prosperity and success they would find ample reward. Mr. Fife seconded the motion, which was agreed to.

Whitehaven.—The Town and Harbour Trust last week considered the following minutes of the Electric Lighting Committee: "8th August. The surveyor was directed to order 20 electric meters from Messrs. Ferranti and Co. 14th August. The engineer was authorised to make arrangements with Dr. Hopkinson in regard to the staff required at the electric generating station. Read letter, dated July 12th, from the Furness Railway Company in respect of an easement rent for the electrical cables crossing the Furness Railway at Coach road level crossing, and the surveyor was instructed to reply that no easement charge was due in respect of this. Read letter, dated 10th July, 1893, from Mr Dees, in respect of an easement rent for crossing the arch of a cellar near the Castle Hotel, Corkickle, the property of Lord Lonsdale. Recommended that the terms and conditions as set forth in the letter be accepted. 21st August.—The surveyor submitted an account which he had received from the Whitehaven United Gas Company, Limited, for repairing damage to gas mains alleged to have been caused by trenching for the electric light cables. The surveyor was instructed to return the account, as the committee do not admit any liability." The Chairman moved the confirmation of these minutes. He did not think there was anything in the minutes that called for observation. They were all aware that the light was turned on on Saturday evening, in the public lamps, and he thought with success. The light was in every way a success, and it was very well they had got it going. Mr. Pattinson seconded the motion, which was carried unanimously. The Chairman said that the next business was to provide money for electric lighting. He proposed that the seal of the Board be affixed to four bonds, in favour of the Cumberland Union Bank, of £700 each, making a total of £2,800 that will be required before the end of the month to meet the expenses of balances of contract; but they are drawn in £700 bonds so that the money need only be drawn when it is wanted to hand over to the contractor. Mr. Hastwell seconded the motion, which was agreed to.

Lighting at Bury.—On the 7th inst. the minutes of the Electric Lighting Committee, bearing the date of 17th ult., were presented at a meeting of the Town Council. The minutes comprised the following report of the borough engineer: "In accordance with your instructions, tenders for the supply of electric light plant have been duly advertised for in various engineering and electrical journals, in accordance with the conditions and particulars approved by you, a copy of which, together with the necessary plans of the compulsory area and site of central station, have been issued to each contractor who has made application. Twenty-four copies of conditions, etc., were originally applied for and issued. Of these seven have been returned, as the parties applying were not able to comply with the terms of the specification, being only part makers of electric light plant, and five firms have kept the conditions, but have not sent in any tender. The following 12 firms, which, with one exception, includes the principal contractors for electric plant, have sent in tenders—viz., Mather and Platt, Limited, Manchester; Laing, Wharton, and Down, London; C. A. Parsons and Co., Newcastle-on-Tyne; Manchester Edison-Swan Company, Manchester; Johnson and Phillips, Kent; Siemens Bros. and Co., Limited, London; the India Rubber, Gutta Percha, and Telegraph Works Company, Limited, London and Silvertown; Woodhouse and Rawson, Limited, Manchester; Crompton and Co., Limited, London; Brush Electrical Engineering Company, Limited, London; J. H. Holmes and Co., Newcastle-on-Tyne; John Fowler and Co., Limited, Leeds. These tenders are now before you. It will be in the remembrance of the committee that the conditions left it optional with the various contractors whether they should tender for 'continuous' or 'alternating' currents, as also the kind of engines and dynamos to be employed, giving the reasons for the adoption of the 'system' and type of machinery which they recommended. This leaves the reports and tenders so wide that it will be necessary for a careful analysis of the tenders to be made before any comparisons can be made as to the initial cost of the working expenses hereafter. This is a matter not only requiring so much care and time, and also so thorough a knowledge of the subject, that it can only be done by one trained as an electrical engineer, and it remains with the committee to determine what course shall be adopted, whether (1) they will call in an expert to analyse the reports and tenders and report to them as to the one most applicable to the borough (paying a fee for such examination and report; or (2) whether they will at once appoint a permanent electrical engineer, who shall, in conjunction with myself, carefully examine the tenders and report (the committee, on receipt of such report, if thought necessary, to pay a fee to an expert to confirm, or otherwise, the report to them); or (3) whether they will appoint a consulting engineer, on commission, to whom the whole of the plans, reports, specifications, and tenders shall be handed to report upon, and who shall have full charge of the works from the commencement to the completion." It was resolved that an electrical engineer be advertised for at a salary of £200 per annum.

Telephony at Glasgow.—At a meeting of the Town Council on 7th inst., Councillor Starke moved the adoption of the minutes of the Special Committee on Telephone Service. The minutes detailed the steps taken to procure a telephone license from the Postmaster-General, and also alluded to the consideration of the question of selecting an engineer who could be consulted by the Corporation with reference to the proposed telephone service. Bailie Primrose moved as an amendment that the application to the Postmaster be approved, but that the other portions of the minutes be remitted back to the committee. He contended that all the committee was instructed to do was to make the application to the Postmaster-General. Bailie Graham seconded the amendment, holding that the committee had exceeded its powers. The Council had not committed itself to the principle of whether or not they should go in for a municipal telephone system. Councillor Colquhoun said he could not understand what Bailie Graham meant when he said that the Town Council had not agreed to the principle of facing a municipal telephone system, because if there was one thing clearer than another the step which the Town Council took in authorising the committee to apply for a license was a distinct affirmation of the principle that the telephone in Glasgow might very well be municipalised. Those who supported that agreed that the telephones ought to be in the hands of the Government. They quite recognised that the telephone system was not a purely municipal matter; but that was not the question they were face to face with to-day. The position of the matter was, briefly, that the Postmaster-General had given a license to the National Telephone Company to carry on a telephonic system in Glasgow until the year 1911. At the time when that license was granted licenses were being granted freely to everybody who applied for them, and as a matter of fact there was another licensee in Glasgow, and if he had stuck to his license and carried on his business, the rents would not have been anything like what they were to-day. As a matter of fact, he had a telephone from the other licensee, and he was enabled on that account to make terms which were £7 or £8 cheaper than anybody else connected with the telephone company. That being so, they, as a municipality, would be foolish if they did not, in the exercise of their rights, go to the Postmaster-General and say, "Give us a license; we have as much right to a license as this telephone company." If they got it, they should adopt the best system. They should lay their telephone system for the city on the twin wire system, and when people had had experience of this they would have nothing to do with the existing system, which, as at present used, resulted in the user hearing everybody's message but the one that he wanted to hear. Whether Glasgow got a license or not, the Government would not be prevented from taking over the system in 1911 if they so decided; and, indeed, a municipality would be more easily dealt with than a private company. The Town Council would simply stultify itself by adopting the amendment. They were under a deep debt of gratitude to Councillor Starke for the immense labour he had taken in this matter, and for the pressure he had brought to bear on the Government. The Postmaster-General dared not now refuse Glasgow a telephone license. After further discussion, the minutes were amended so as to read that no engineer should be engaged till the answer of the Government to the application should have been received and a solution thereupon have been come to.

Barrow Lighting.—The subject of electric lighting came up again for consideration at the monthly meeting of the County Council on the 4th inst. In accordance with notice, Councillor Smith moved, "That in order to ascertain whether there is any demand for the electric light a circular be sent to each householder in the centre of the town asking them to state whether they would be prepared to take a supply, and, if so, to what extent." He said after the considerable length of time he had occupied the Council on the two previous occasions in which he had brought the electric light question forward, it was not now necessary for him to take more than one moment in proposing his motion. So far as the discussion went on the two previous occasions, and so far as he had had the opportunity of getting the opinions of members outside, there seemed to be a great unanimity of opinion as to the many advantages obtainable over other sorts of illumination. He would only point out that the issue seemed to be as to whether the present was an opportune time or not. The chief objection before to the scheme proposed was, that although it had been successful in other towns, Barrow was in a different position to other towns, and if it was established here there would be no demand for it. That was the chief objection, and he was now asking the Council to issue circulars to test as to whether his notion that there would be a demand was a correct one or not. Councillor Wansbrough seconded. Alderman Strongitharm said it seemed to him that Councillor Smith had rather put the cart before the horse. At the last meeting of the Council this question of electric lighting was thoroughly discussed, and the Council had a report from the Gas and Water Committee submitted to them dealing with the question. At that time Councillor Smith moved that the Electric Lighting Sub-Committee be authorised to provide a provisional order. The motion, however, was lost by 16 votes to seven, and an amendment by Councillor Wansbrough that the matter be referred to the borough engineer for a report thereon was lost by 17 votes to six. He submitted now that there was no necessity for going on with the matter. At the last meeting he moved the amendment that a provisional order for electric light be not sought, because there was absolutely

demand whatever for it in the town. That seemed to be the view taken by the Council, judging by the large number who voted for the amendment. They had done this previously—24th October, 1890—and circumstances had not changed since then. In that year circulars were issued with the following: "Would you be disposed to take the electric light in the event of its being supplied in accordance with the terms of the annexed letter." Out of 805 circulars issued to householders, and to show the little amount of interest taken in it, 350 were returned with no answer. Only 25, or 3 per cent., replied that they were willing to take the electric light if supplied, 421 stating emphatically "No" (thus 50 per cent. refused to take it), and 350 persons never replied to the circular. He thought that proved pretty conclusively that there was no desire at that time to go in for the electric light. As he pointed out upon the last occasion, it seemed to him that it was very desirable to let the matter rest where it was. It had been already stated that, considering the present position of the town, they should not incur any expenditure further upon current capital account, they having spent £30,000 or £40,000, and practically the whole of which was unremunerative. Already the Electric Lighting Sub-Committee had spent between £40 and £50 in getting information relative to the electric light. He did not think they should go in for it at present, as there was really no legitimate demand for it. If there was a demand it should be made spontaneously by the people of the town. They should memorialise the Corporation if they desired to have the electric light, and the Corporation would take any request into consideration. He should oppose the proposition. After further discussion the motion was adopted.

Electricity and Sewage Disposal. This question was referred to in our last issue in connection with the meeting of the Monmouth Town Council, and we now give the following additional information. Mr. W. Honeyfield (the mayor) said that when last they had the question of drainage before them it was to receive the schemes sent in, in answer to advertisement. In all the schemes sent in they were asked to supply a motive power—either steam, oil, or gas. They had, he thought, sufficient water power running through the town, and he did not know why it could not be utilised, thereby reducing the yearly cost of purification. The only objection he could see to the water being used as a motive power would be by the Board of Conservators. They (the Council) would take the water out at one point and put it in at another, and therefore the Conservators would have no reason to interfere. All the sewage would gravitate to a spot between the Mayhill viaduct and the Redbrook road, and would be there lifted by hydraulic power to just below the Hill Farm, on a piece of land near the viaduct. By selecting that site for the purification works, it was out of sight of the town. They were called upon to provide motive power for the removal of the sewage. If they could get sufficient water power they might try an electrical installation. He was aware that in mentioning electricity he was putting his head into a hornet's nest, but the figures he should roughly put before them would, he believed, justify him in doing so. They had to consider the public good. If they could see their way clear to reducing the public expenditure, it was their duty to do so. He knew that water could be utilised, but he found that the electrical installation for 100 public lamps could not be done so economically as a larger one. The question was, had they sufficient power available to drive an electrical installation of 100 public lamps and 500 private ones? He had been in communication with electrical and hydraulic engineers upon that point, and he thought that from the figures he should place before them (the Council) it would justify him in asking them to appoint a committee to go deeper into the question. As far as he could ascertain, the cost of installation for 600 lamps would be about £2,500; that figure was taken from an installation of 2,000. Consequently it might work out in actual practice higher than it was there. The permanent yearly expenses would be about £382. By combining the electrical station with the purification works, part of the labour would be available to attend to the sewage. The Council paid the gas company something like £320 per year for gas. The income from 500 private lamps at 15s. each would be £375; the total income would be £693. The yearly expenses would be £382, and the repayment of the loan in 30 years by equal annual instalments would be £136, leaving a balance of £175 to the good. The yearly cost of the sewage purification was put at £150. That included the expenses of two men and a boy. By combining the two schemes his opinion was that they could do with one man less for the electrical station, thereby bringing down the expenses to £100 per year. Those figures were not his own, but those of a practical electrician, and the figures with reference to the sewage were by an engineer. His (the Mayor's) opinion at the present time was that if they combined the two schemes the profit of the one would pay the expenses of the other; even when they were repaying the loan. Then, again, if the private installation exceeded 500 lamps, every lamp they could get out would add to the annual income. He did not ask them to decide upon the sewage or electrical part of the scheme that day, but he thought after giving them those figures he would be justified in asking the Council to form a small committee, not exceeding five members, with authority to spend upon the electrical portion of the scheme, say, £10, for which sum they could get both the opinion of electrical and hydraulic engineers. They would examine the ground, prepare plans, and give an estimate of the cost. They (the Council) could then see if it was practicable, and if so, they would have reliable figures before them, and they could then make up their minds whether they would have it or not. On the proposition of Alderman Hyam, the Mayor was requested to appoint his own committee, and the sum of £10 was voted to them for the purpose mentioned.

PROVISIONAL PATENTS, 1893.

SEPTEMBER 4.

16571. **Improvements in signal, telegraph, or other posts.** Illius Augustus Timmis, 2, Great George-street, Westminster, London.

16594. **Improvements in electrical means of advertising.** Alfred Rene Upward, 150, Holland road, Kensington, London.

16597. **Improved inspissated oil for electrical insulating purposes, and method of producing same.** Adolf Gentzsch, 55, Chancery lane, London.

16630. **Improvements in obtaining zinc from solutions by electro deposition.** Benedict Kitto and William Muir, 30, St. Swithin's-lane, London.

SEPTEMBER 5.

16699. **Improvements in electric cranes.** Walter Pitt, 24, Southampton buildings, Chancery lane, London.

16702. **Improvements in electro-coils for the administration of electricity to human beings, for medical purposes or others.** Edmond Savary d'Odiardi and Eva Savary d'Odiardi, 43, Cornwall gardens, London.

SEPTEMBER 6.

16746. **Improvements in the design and manufacture of polarisation plates for electric apparatus, and frames or holders for same.** George James Davis Overton, Ormeley road, Balham, London.

16770. **Improvements in electrical connections to floating vessels, balloons, buoys, and the like.** George Morison Hamlyn, 28, Southampton-buildings, Chancery-lane, London.

SEPTEMBER 7.

16836. **Improvements in or appertaining to incandescent electric lamps.** William Phillips Thompson, 6, Lord-street, Liverpool. (Otto Berndt, Germany.)

16851. **Improved insulating material for electrical purposes and method of producing same.** Adolf Gentzsch, 55, Chancery lane, London.

16880. **Improvements relating to the coating of plates, wire, and other metal articles by electro-deposition to protect the same from corrosion, and apparatus therefor.** Sherard Osborn Cowper Coles, 45, Southampton buildings, Chancery lane, London.

SEPTEMBER 8.

16912. **Improvements in electric current meters.** Michael Birt Field, Claremont, Woodberry Down, London.

16923. **Improvements in or relating to means or apparatus for preventing unauthorised persons overhearing private conversations by or through the telephone.** Charles Edward Peniston, 323, High Holborn, London.

SPECIFICATIONS PUBLISHED.

1892.

14533. **Converting alternating currents of electricity into direct currents.** Lucas and New.

15197. **Electrolytic apparatus.** Andreoli.

17423. **Supplying electricity to vehicles.** Chabeault.

18666. **Electrolytic decomposition of compounds of metals and sulphur.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

19242. **Cases for electric batteries, etc.** Oblasser and Théryc.

1893.

4910. **Electric switches.** Joseph.

4911. **Electric lampholders.** Joseph.

4912. **Electric lamps.** Joseph.

9290. **Electrolysis of salt.** Craney.

9965. **Electrically working and welding metals.** Longsdon. (Krupp.)

11579. **Electrically welding metal.** Thompson. (Coffin.)

13489. **Electric bell.** Zeitschel.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
City of London	—	11
— Pref	—	12¾
Electric Construction	—	—
Gatti's	—	5¼
House-to-House	5	5⅝
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	6½
National Telephone	5	4¾
St. James', Pref.	—	8
Swan United	3½	3¼
Westminster Electric	—	5¼

NOTES.

Church - Lighting. — The church of St. Botolph, Bishopsgate, is now lighted by electricity.

Tunnel - Lighting.—The recent railway accident in the Box Tunnel suggests the idea of lighting long tunnels by electricity.

The Wembley Tower.—An electric arc lamp or search-light of enormous candle-power is to be erected at the top of this tower.

British Association.—The meeting next year will take place at Ipswich, and the Marquis of Salisbury has been chosen president.

Brighton.—The sea-front was lighted by electricity for the first time on Saturday evening. There are 40 arc lamps of 1,000 c.p. placed at distances of about 40 yards apart.

Italian Electric Tramways.—A company has been formed for the purpose of constructing an electric tramway in Varese, and a similar line is projected between Argegno and Lanzo d'Intelvi.

German Central Station.—The central station at Stettin has a total length of supply mains of about 28 miles wholly composed of Siemens cable, lead covered and wound with iron tape.

The Post Office and the Telephone.—It is stated that the agreement between the Postmaster-General and the telephone company will not be laid on the table of the House of Commons until the autumn sitting.

Travelling Torpedo.—Some experiments with a travelling torpedo have just been carried out at the torpedo station established near Fort Mingam, at Brest. The trial of the new torpedo is said to have been a success.

Railway "Fogging."—The agitation now proceeding among the "foggers" in the Metropolis should tend to induce the railway companies to introduce either a mechanical or electrical system of placing the detonators on the metals.

Conduits.—The catalogue issued by Messrs. Ropkins and Co., Limited, of Wisbech, contains designs of sections of electric cable conduits and examples of mouldings and skirtings worked for electric and telephone wire casings and covers.

Exhibition at Madrid.—A universal exhibition is to be held at Madrid from April to October of next year, one section being devoted to electricity. The English agents for the exhibition are at 21, Great Newport-street, St. Martin's-lane, W.C.

Exhibition at Newcastle.—It is proposed to hold from November 6 to December 2 next, in the St. George's Drill-hall, an industrial, electrical, and general trade manufacturers' exhibition, illustrative of engineering inventions—mining, electrical, etc.

Skeleton Keys Doomed.—An ingenious Frenchman, named Langlassé, has devised a simple arrangement of electrical contacts for door locks which, during the hours when no watch is kept, will give notice by ringing a bell of any attempt at opening the door by means of false keys or pick locks.

Electro-Harmonic Society.—A smoking concert will take place next Friday, the 29th inst., at the St. James's Hall Restaurant (Banquet-room), Regent-street, W., commencing at 8 p.m. There is a strong and attractive programme, and members are invited to turn up in good numbers.

Edinburgh Tramways.—The Corporation are inviting offers for the lease of the tramways, and Mr. Wm. White Millar, of 8, George street, Edinburgh, will supply particulars. We wonder whether there is any chance for electric traction. At any rate, proposals must reach the town clerk on or before the 29th inst.

Cheap Incandescent Lamps.—We are informed that the Edison and Swan United Electric Light Company, Limited, have, from yesterday, reduced the prices of incandescent lamps of standard sizes from 3s. 9d. to 1s. 9d. The excellence of the quality of the lamps will be maintained, and no inferior lamps will be placed on the market by the company.

Search lights.—Some interesting experiments have been made at Lydd in shell firing at night at an object representing a ship rapidly moving across the ranges. The shells were supposed to be fired from a land fort at an enemy's ship at night. For the purpose of discovering the object electric search-lights were used, for which an installation was temporarily put down at the camp.

New Portable Lamp.—At a meeting of the North Staffordshire Mining Institute at Stoke on Monday, Mr. Doubleday read a paper on a portable electric lamp devised by Mr. Sax Sussman. The lamp is 2¾in. square and 8in. high, and its total weight is 3½lb. It gives a steady, clear light, of a power, it is said, superior to the best modern safety oil lamp. It gives a light for 16 hours.

Installation Work.—Before the London Association of Foremen Engineers and Draughtsmen, Mr. W. P. Heath recently read a paper on "Electrical Installation, Wiring, and Fitting." Among other matters, he mentioned that in new buildings intended to be lighted by electricity, architects were now making provision for the wires to be carried down chases in the walls, just as they made provision for drain and other pipes.

Laundry Exhibition.—At the Laundry Exhibition, which closes at the Agricultural Hall to-morrow, Messrs. Crossley Bros. show an "Otto" gas-engine which drives a Crompton dynamo energising four arc lamps. Messrs. Ullathorne and Edmondson, of Bradford, exhibit a dynamo lighting arc and incandescent lamps, and an electric ironing apparatus, the roller being heated by the electric current. Messrs. Glover and Hobson, of St. James's-road, S.E., have on view a new engine, termed the "Williams," and which is described in another column.

Treatment of Sewage.—A new system of treating town sewage is being tested in London, specially with a view of dealing with the drainage of seaside towns. The idea is that of electrically treating sea-water, and thereby effecting such chemical changes as to render it a powerful disinfecting solution. A portable engine is used, the dynamo for supplying the current being bolted to its carriage, and the new disinfectant is pumped into the sewers by the same engine, a hydraulic sewer-flushing apparatus being employed so as to obtain the greatest effect.

Zambesia.—The Portuguese Government has formally confirmed the contract of March 28 last with the Portuguese Companhia Zambesia, conferring upon it exclusive rights for the construction of a network of telegraphs between the Zambesi Tête, Quilimane, Chinde, and other localities. Besides the cable connecting Quilimane and Mozambique, pursuant to Article 11 of the Anglo-Portuguese treaty, the Government is empowered to compel the company to make telegraphic connections across Portuguese territory between the opposite frontiers, reaching the latter from British territory.

Speed of Vessels.—Mr. Edison's latest suggestion concerns the amount of speed lost in a vessel owing to the friction of the water upon her sides. He claims that by

producing hydrogen by electricity along the sides of the ship, which he has tested by a model in a tank to be practicable, he can reduce the friction of the water to a minimum. Unfortunately, when he tried the same experiment in genuine salt water at Sandy Hook the results were not so satisfactory. Another scheme is to force oil of an inferior quality through the pores of the underwater-line plates of a vessel.

Discharging Point of Lightning Protectors.—According to an article written by M. Precht for *Wiedemann's Annalen*, a discharge from lightning protectors is only produced when the potential exceeds 15,000 volts. Extremely fine terminal points have even been charged up to 25,000 volts without obtaining a regular discharge. The presence of dust in large quantities, or of gas round the discharging points, makes the discharge apparently less easy, whilst the concentration of ultra-violet light upon them facilitates it. A group of points can be charged to a higher potential than a single one.

Prize for New Battery.—Sometime ago, *L'Elettricità*—an Italian technical paper published in Milan—offered a prize of 2,000 lira (= £80) for a new electric battery which should fulfil certain conditions. The time during which the competition remained open was twice extended, but definitely closed at the end of last year. It is now announced that the result of the competition has not been in any respect equal to what was hoped: none of the batteries entered for the prize fulfilled all the necessary conditions, and only one—viz., that devised by Prof. R. Rosati, of Florence—comes within the range of honourable mention.

Fire Alarm.—The attention of the Paris Academy of Science has been directed by MM. Delahaye and Boutille to an ingenious application of electricity as a fire alarm. A small ball of aluminium is supported at one end of an arm, with a counterpoise at the other, the apparatus being in equilibrium at any ordinary pressure and temperature of the air. If, however, the specific gravity of the atmosphere of a room is considerably diminished either by a rise of temperature or an admixture of coal gas in sufficient amount to become explosive, the balance is destroyed, and the ball in falling completes an electric circuit by which an alarm bell is set ringing until the normal state of affairs is re-established.

Glasgow and West of Scotland Technical College.—The main objects of this college, the calendar of which for 1893-94 has just been published, are to provide a suitable education for those desiring to qualify for an industrial profession or trade, and to train teachers for technical schools. There are both day and evening classes. In the case of the former, regular courses have been arranged in, among others, civil engineering, mechanical and electrical engineering, naval architecture, mining engineering, mathematics and physics, and chemistry. Similar courses have been organised in the evening classes. The details of each course are contained in the calendar, and any further information may be obtained at the office of the secretary, 38, Bath street, Glasgow.

Institution of Electrical Engineers.—The Council believe that a time must arrive when a benevolent fund in connection with the Institution will be found desirable for the assistance of necessitous members and their families, or the families of deceased members, and they have therefore established such a fund, termed the "Benevolent Fund of the Institution of Electrical Engineers." The fund will be managed and administered on lines similar to those which govern the benevolent fund of the Institution of Civil Engineers. The Council trust that all members will assist the fund personally, and also by using their influence to obtain subscriptions and donations from friends interested in the profession. The secretary of the Institution will be happy to receive subscriptions or donations.

Feed-Water Heaters.—We have received a copy of the new price list issued by Wright's Patent Heater Condenser Company, of 16, Great George-street, Westminster. It is to be noted that the improved Berryman feed-water heater, which is made by the company, has been adopted with satisfactory results by, among others, two or three electric supply companies in the metropolis and by various prominent electrical contractors. By the use of Wright's injector surface condenser and steam-water refrigerator it is claimed that a saving in coal is effected of from 20 to 60 per cent., and in water of from 80 to 90 per cent. A description is given of Wright's compound-cylinder release engine, which is shown coupled direct to a dynamo. The list will be of interest to steam users generally.

German Electrical Engineers.—The Union of German Electrical Engineers, recently formed in Berlin for the purpose of dealing with both commercial and technical matters relating to electrical engineering, will hold their first annual meeting at Cologne between the 27th and the 30th inst. Papers on the following subjects will be read: "Impressions of the Chicago Exhibition and the Electrical Congress," by Dr. Budde; "On a System of Measurements for Central Electric Stations," by Dr. Kallmann; "Charging Accumulators by means of Alternating-Current Machines," by Mr. Pollak; "On the Development of House and Private Telegraphs and Telephones in Connection with the Imperial Post," by Dr. Sack; and "On a New Insulation Testing Set, and an Incandescent Lamp Resistance," by Dr. Heim.

The Glasgow and Belfast Telephone.—Some four months ago, at a cost of about £20,000, the Post Office laid down a telephone between Glasgow and Belfast. The tariff, however, was so high—namely, 5s. for three minutes' conversation—that for two months no business was transacted. The price was then reduced to 3s., or 1s. a minute, and since this reduction, which took place on July 28, there have been six conversations across the wire. One of these extended to nine minutes, thus costing the caller-up 9s. By an arrangement just entered into with the National Telephone Company there are to be increased facilities for telephonic communication between the two commercial capitals, which should lead to extended business. Subscribers can now get switched on to Belfast from their places of business.

Controlling Clocks by Electricity.—Mention was made in a previous issue of a system of controlling clocks by electricity, devised by Herr von Hefner-Alteneck. It consists in simply incorporating the control system with the electric light or power installation already existing by means of a particular form of clock which is placed in circuit like an ordinary incandescent lamp. It is kept wound up by the current at an annual cost not exceeding 9d. for 24 hours, and in the case of interruption of the circuit the clock will, it is said, go for about 12 hours independently of the circuit. The control is effected once a day by a momentary drop of the circuit potential by about from six to ten volts at 5 a.m., which has the effect of setting all the clocks in the circuit at five. The effect on the lamps is inappreciable, and the control can be performed by hand in the dynamo-room or automatically.

Science and Art.—The latest edition of the "Science and Art Directory," just issued by the South Kensington authorities, contains some interesting figures on the progress that is being made in the teaching of science and art. Last

year there were 180,410 pupils under instruction in science, 108,858 of whom were examined, the number of papers worked by them being 203,347, out of which 136,778 were accounted worthy of the "pass," while 35,932 were placed in the first class. These figures show a marked advance on the previous year, the grant from South Kensington being £123,647, in addition to sums granted out of the Imperial subvention of £750,000 under the Local Taxation Act, a large portion of which is now devoted to science and art teaching. Last year South Kensington granted £133,008 to elementary schools in aid of the teaching of drawing, while £56,317 was paid to schools of art. The total expenditure of the Science and Art Department was £635,470, out of which £37,260 was for administrative purposes.

Ocean Telephony.—A paper on this subject was presented by Prof. S. P. Thompson at the recent electrical congress at Chicago. At present, ocean telephony over any considerable distance is impracticable owing to the retardation of the signals, and even rapid automatic sending is out of the question. This retardation of the signals is due to the electrostatic capacity of the cable, which is distributed uniformly along the whole length of the line, and cannot be corrected by compensating devices fitted at the ends of the cable. A distributed remedy is wanted, and this Prof. Thompson proposes to obtain by using electromagnetic induction to correct the retarding effects of the electrostatic capacity of the cable. This he does by constructing the cable on a three-wire system, two of which are to form the complete circuit, whilst the third constitutes an inductive shunt connecting these two wires at intervals. Such a cable would cost considerably more to construct than an ordinary cable, but Prof. Thompson claims that it would do 10 times as much work.

Decimal Weights and Measures.—At the Engineering Congress held at Chicago on August 1, and which was attended by leading members of the profession from many countries, a paper on the fundamental units of measure was read by Mr. T. C. Mendenhall, superintendent of the United States Coast and Geodetic Survey, as well as superintendent of the standard weights and measures at Washington. Mr. Mendenhall stated, *inter alia*, that the office of weights and measures at Washington, with the approval of the Secretary of the Treasury, would in the future regard the international prototype metre and kilogram as fundamental standards; and the customary units, the yard and the pound, would, as from April 5, 1893, be treated as derived therefrom. This amounts to an official notification that the United States have formally adopted the metre as the standard of measurement. In future the yard will be represented as a fraction of the metre, and the pound as a fraction of the kilogram, in the Washington Office of Weights and Measures. This is a great step towards the introduction of the metric system in the United States.

Electricity in Military Operations.—An interesting night attack, devised by and carried out under the superintendence of Major-General Geary, R.A., was made at Portsmouth on Wednesday evening. Besides the primary object, which was to determine how far the electric light of shore defences is efficient for the lighting up of vessels attempting to approach the harbour, the affair had something of the nature of a surprise, and was intended to test the mobilisation scheme for the defence of the eastern entrance to Spithead. The field of operation extended on the north from the Warner light-vessel to Fort Cumberland, and thence along the coast to Fort Gilkicker, and on the south from the Warner along the shore of the Isle of Wight as far as Ryde. The operations were appointed to take place at about eight o'clock, but it was not until close upon nine that the firing of a rocket announced the beginning of the attack. The fight continued until ten o'clock, when the flashing of the search-lights skyward conveyed the order to the troops to return to barracks. As far as observation went, remarks a correspondent, the electric lights appeared too feeble for the purposes contemplated.

Gas and Electric Light.—Mr. E. C. Riley, president of the South West of England District Association of Gas Managers, remarked last week, at a meeting of the society at Exmouth, that the two great rivals recognised by them were first petroleum, and, secondly, the electric light. He illustrated this, in the case of electricity, by stating that a large company having a private works for their own gas supply obtained a fine installation of the electric light; with the result that the quantity of gas required from their own works was reduced by from one-third to one-half. But since the completion of the installation, from various sources—such as the extended use of gas for special industrial processes, and to avoid the cost of the provision of day current, when the work on the dynamos would be so unprofitably light—the consumption of gas had quietly and steadily grown, so as to have nearly attained the same figure as before the electric light was introduced. It appeared to him that the moral of this illustration was that gas managers should take every opportunity of showing the real value and usefulness of gas, and that special efforts should be made to adapt its use to special purposes. This view of the matter is certainly very sensible.

Poor Light.—The hotel proprietors and restaurant keepers of Avignon, says *Electricité*, have sent in a petition to the Municipal Council of that city, wherein they allege a serious falling off in the candle power of their electric lights, and ask that the authorities shall intervene in order to ascertain whether the lighting power given by the lamps furnished by the electric lighting company is in accordance with the undertaking entered into with each subscriber. It is more than doubtful whether the authorities will take any action in the matter, as they practically are unable to do so; they have merely given to the company a right of way, and that is all. The lesson to be learnt from such a dispute is that contracts to supply so many lights at a fixed rate for a given candle-power are most unsatisfactory in daily work, and no system of this kind can supersede in excellence or be fairer than the use of meters. In regard to defective pressure, it would seem, however, to be essentially the part of public authorities who have rights to give electric lighting companies to secure a reasonable service from the latter, and any excessive variation of pressure in the public supply ought, as a primary condition, to be forbidden. The local newspaper press claims, however, that the town-lighting leaves nothing to be desired.

Ediswan Portable Batteries.—A large variety of portable secondary batteries for different purposes is being manufactured by the Edison and Swan United Electric Light Company, Limited. The batteries are made in various sizes to suit particular requirements. For instance, the A type is the smallest size made, comprising two cells suitable for placing in the pocket to energise lamps arranged in scarf pins, head dresses, jewellery, flowers, etc., and intended specially for theatrical and music-hall use, and for surgical and dental work. A light of from two and a half to three hours per charge can be obtained with these batteries by the use of lamps of about 3·7 volts. The B type of battery is intended for similar purposes; it is larger and yields per charge a light for five hours. For the illumination of railway carriages and tramcars the C type has been designed, and by combining two, three, or more, batteries of any re-

quired power may be obtained. Batteries of this kind are also made to meet the requirements of medical men. A convenient form of hand lamp capable of extensive employment is provided by the D type of battery and lamp. It weighs 7lb., and gives a light of 1 c.p. for 10 hours. Full particulars and illustrations of these batteries are given in the company's new catalogue, Section 6, which has just been issued. In addition, the list contains instructions for the charging of the batteries, etc., together with prices.

Alternating Currents of Constant Frequency. A recent issue of the *American Journal of Science* contains a paper by M. J. Pupin, describing a method of obtaining alternating currents of constant and easily-determined frequency. For this purpose he uses a small transformer whose primary circuit contains an interrupter of peculiar design. This consists of a stiff brass wire, stretched between the pole-pieces of two permanent horseshoe magnets, and carrying at its middle point a short amalgamated copper wire. At every vibration this copper wire dips into a mercury-cup and closes the circuit of a battery; the repulsion between the current in the wire and the magnets serving to keep up the vibrations. The tension, which can be adjusted without stopping the vibrations, is altered until the wire is in unison with a tuning-fork of known pitch. In order to diminish the intensity of the harmonics which are present when the current is interrupted in this way, the primary of the transformer is joined in series with another coil having a movable iron core, and in parallel with a condenser of variable capacity. The capacity and self-induction of the circuit are by these means altered till the natural period of the circuit corresponds with the fundamental of the wire. The attainment of this condition is shown by the sparking at the break being a minimum. Under these circumstances the circuits acts as a resonator, and selects from the complex E.M.F. that harmonic with which it is in resonance, and strengthens it.

Electric Light Letters for Advertising.—An important advertising novelty is now being introduced in London in the shape of electric letters formed of bright plated metal backing, of hollow section, mounted on a board to any possible design. Into these backings glass tubes of uniform diameter and various lengths, enclosing a filament, are fitted. The tubes are joined in circuit, without any artificial resistance being used, so that the electric light letters are joined direct to the lighting-main as if they were ordinary incandescent lamps. The appearance of the electric light advertisements or signs, etc., formed of these letters, which are of particularly attractive and tasteful design, is of so unusual and striking a character that they form a most powerful means of arresting and sustaining the attention of the public. These electric light advertisements can be arranged to switch themselves on at dusk and off at daylight. The letters and signs, which are made complete, and are mounted ready for erection, by the Edison and Swan United Electric Light Company, Limited, at their Ponder's End works, are specially suited for theatres, railway stations, exhibitions, restaurants, hotels, shops, for advertisements in tunnels, underground railways, and every other place where an ordinary advertisement would be useless. Attention is particularly drawn to one out of numberless effective applications to which these signs can be adapted—namely, for shop fronts, the name of the proprietor being formed by these electric light letters mounted on a skeleton frame suspended in the window, affording a brilliant advertisement and a brilliant light, thus rendering any other form of window-lighting unnecessary. We understand that the Electrical Advertising Syndicate, Limited, are the proprietors of the invention, and are already erecting these signs in London The sign "Partington," shown in Charing Cross underground railway station, is an example of the most recent type of letter. The letters in question have been designed by Mr. Réné Upward, who is consulting engineer to the syndicate

High-Frequency Discharges.—We have received a copy of a reprint of an article in the September issue of the *Philosophical Magazine* on "Experiments with High-Frequency Discharges," by Mr. A. A. C. Swinton. The author, by employing the apparatus described in that magazine for February, 1893, for producing electric discharges of high potential and high frequency, has obtained several curious effects. A flat tin dish filled to a depth of about ½in. with rosin oil was electrically connected to one terminal of the high-frequency coil, and a wire connected to the other terminal of the coil was suspended with its extremity about 3in. or 4in. above the surface of the oil in the dish. On putting the coil in action, the oil was immediately thrown into a state of violent agitation, the whole surface bubbling and foaming, while the oil gradually crept up the inclined sides of the dish in a well-defined wave, and finally overflowed. The effect appears to be due in great measure to the violent repulsion of the particles of air from the suspended wire into the oil. A similar result was obtained when alcohol was substituted for oil in the dish, but the alcohol immediately caught fire. With ordinary paraffin oil the effect was the same and the oil caught fire, but only continued to burn so long as the electric discharge which supplied the additional heat necessary to keep the oil burning was maintained. Distilled water was next tried, but with this no agitation of the surface or creeping-up of the liquid ensued. When, however, the suspended wire was lowered so as to touch the surface of the water, an octopus-like figure of bright sparks, about 2in. to 3in. in diameter, was formed on the surface of the water, and even when the wire was further lowered so as to dip three-eighths of an inch into the water, so that the point of the wire was within one-eighth of an inch of the tin dish, the sparks still spread out, leaving the wire at its intersection with the surface of the water, and not at the point of the wire, which, as already mentioned, was within one-eighth of an inch of the tin dish. In fact, it was not until the point of the wire and the dish were brought very nearly into contact that the discharge took place through the water, which it then did with very white sparks producing small explosions, and the sparks on the surface ceased.

The Government and Telephony.—On the resolution for the post office and telegraph service on Tuesday evening, Mr. Henniker Heaton said that a grosser blunder had never been committed than for the Post Office to keep in their own hands the unproductive trunk telephone lines while they have left the paying local lines in the hands of the private companies. Sir A. Rollit spoke of the great interest which the municipalities had shown in the telephone, and considered that what was now proposed was not a restriction upon municipal action. It was not correct to say that the charge for the telephone was £20. When all the circumstances were taken into account he found that the average charge in London was £15, and in the provinces £8. 16s. He would not express an opinion as to whether a lower price would pay. His view was that the work should be done in the best form, in the belief that really good public service would in the end be most remunerative. The administration of the Department in this matter, both by the Postmaster-General and by his predecessor, had been such as to lead the company to desire nothing that was not fair and reasonable. Their desire was to consult the public

interests, and he could assure the right hon. gentleman that in the negotiations in regard to the agreement they would do their best with him to arrive at a right and fair conclusion. Mr. A. C. Morton said, in his view the telephone companies wanted what was unfair and unreasonable. Their object was to secure by the aid of the Government a permanent monopoly. All he wished to say now was that the Act of last year was rushed through the House in a great hurry. He did not object to the Government purchasing the main lines, but he trusted that the Postmaster General would do nothing to assist a monopoly. Mr. A. Morley, in reply, said he did not think he could be fairly called upon to make a declaration at the present time as to the policy of the Government with respect to the telephones. New developments which had recently come to the front would have to be carefully considered. One of the most important recommendations of the Joint Committee was that telephone companies licensed by the Post Office should have statutory powers for obtaining way-leaves and underground means for laying their wires. He thought, however, that those powers ought to be subject, as they were now, to the assent of the local authorities, which had control over the thoroughfares of our great towns and municipal areas. With regard to the agreement between the Post Office and the National Telephone Company, the heads of which were drawn up by the late Government, he remarked that a very strong case would have to be made out that would justify the House in departing from the terms of the agreement.

Death by Lightning in France.—According to statistics, the average number of deaths caused by lightning in France between 1835 and 1883 amounted to 100 annually. From one year to another, however, the number of victims is very variable. The number of those struck, but not fatally, is about five times greater on an average than those killed outright. The year 1890 was exceptional for the frequency and violence of its thunderstorms, and the number of persons struck, as well as of persons killed, shows a like increase. The effects of the "thunderbolt," as it is popularly called, are variable, according as the person is struck directly or by *contre-coup*. The lesions *en évidence*, remarks the *Lancet*, take the form of burns or lacerations, insufficient by themselves to account for death, which is sometimes instantaneous, and is sometimes preceded by an agony more or less prolonged. Pathology has not said the last word as to how death is caused. Some French physicians ascribe it to "cerebral perturbation which paralyses the bulb"; others to "electrolytic decomposition of the tissues and the liquids"; and others, again, to the "evolution of a gas in the vessels of the circulation." The bodies of persons struck by lightning present phenomena quite fantastic, in their form especially. On some, the scorching assumes an almost artistic configuration, insomuch that more than one observer has traced these "designs" or "lightning drawings" not to chance, but to the "outlines of objects that happen to be in the immediate neighbourhood of the victim when struck by the thunderbolt"—the phenomenon being one of "reproduction or transference." Sometimes these figurings assume arborescent or tree-like forms. If death is not instantaneous the effects are very variable, according to the constitution or state of health of the individual, or according to the circumstances in which the visitation occurs. Dr Nothnagel, professor of clinical medicine in the Vienna School, has made a special study of "stroke by lightning," and has reproduced the phenomenon in question on rabbits by means of a Leyden jar. In a recent lecture he described the non-characteristic of the external manifestations of the person struck and also the first steps that should be taken for his recovery. His observations have special interest as regards the effect of the "stroke" on the brain, on the spinal marrow, and on the peripheral nerves, particularly as to loss of consciousness, cerebral disturbances, and ataxic complications. Shock to the visual organs and partial paralysis of the tongue—this latter being sometimes peculiarly unresponsive to treatment—were amongst the symptoms more distinctively characteristic of the lesion; others, again, bore an affinity to the nervous perturbations induced by railway collisions or by accidents which affect violently and suddenly the mental or emotional faculties.

The Fatal Accident.—The enquiry held on the 15th inst. with reference to the death of Mr. W. Ball at the Blackfriars transformer station, and which was dealt with in our last issue, has been adjourned for three weeks to allow of the attendance of the assistant Meech, who was injured at the same time. Mr. A. C. Langham, deputy coroner for Southwark, conducted the enquiry, and Major P. Cardew represented the Board of Trade. Philip Hunt stated that on Tuesday evening, about half past six o'clock, he was called into the provider-house of the London Electric Supply Corporation, where he found the deceased lying on the floor between two converters and a stool. He appeared to be dead. A young man named Meech was at the door, very badly burned. The witness at once telephoned to one of the other stations for assistance. Meech, when he saw witness, said that whilst he was dusting down they had turned the main on, but witness found that that was not the case, as on looking up he found that the switch gear was down. Witness was not employed by the corporation, but he worked on the same premises. He thought that if they had turned on the switch they would have first telephoned through from Deptford. J. G. Freeman, the engineer in charge of the London Electric Supply Corporation's station at Blackfriars, stated that on receiving the telephone message for help he at once took a cab, and arrived at the Blackfriars station shortly after 7 o'clock. Meech, the assistant lineman, was sitting on a stool, whilst Ball was lying on the ground dead, with outstretched arms, near to transformer 42. Looking round to discover how the deceased might have received a shock, he found a duster lying on the terminal of the transformer. Witness was of opinion that the deceased had received the shock from the omnibus bar whilst engaged in dusting. The deceased had been in the Corporation's employment for a number of years. He was always a very careful man, and must have been aware of the danger he incurred when dusting with the plug in the omnibus bar. The deceased was the only person to blame in the matter. Mr. P. W. D'Alton, engineer-in-chief to the London Electric Supply Corporation, said the deceased had the reputation of being an exceptionally careful, trustworthy man, and that he knew every bolt in the building. It had been a piece of lamentable forgetfulness on his part not to have removed the plug before commencing to dust. Meech's duty required no previous knowledge of electricity. Notices with "Dangerous" on them were posted over the machinery. Dr. Hamilton, house surgeon at Guy's Hospital, said he saw the deceased between seven and eight on the Tuesday evening. There was a ragged wound on the back of his right wrist and hand, and the flesh was charred and smelt of burning. There was also a smaller wound on the back of the left wrist, and the injuries had the appearance of having been caused through contact with electricity. Other evid[illegible] showed that Meech had been badly burn[illegible] enquiry was adjourned, as mentione[illegible] attendance.

ELECTRIC SUPPLY COMPANIES.—I.

The world electrical moves fast, not so fast in some directions as electrical engineers and the world in general would doubtless like, for electric traction still lags, and the telephone, though with us, is not yet for us in the way we would desire. Nevertheless, it moves, this world of matters electrical, and those in it and of it, while pushing their hardest at the great fly wheel of applied science, sometimes see only the increased activity in their own corner, and wonder how matters are really progressing among their fellow-compeers. Another season is upon us, and after the outward movement of individuals on their holidays, abroad, or even to Chicago, the reconcentration will commence upon the serious work of the season, plans are laid for future extensions, papers will be read, new developments, new inventions brought forward and discussed, and so the progress of electrical engineering goes on. How has it gone during the last year or two amongst the large concerns—electric lighting companies and their stations especially? This is a question many will be asking, and a question we shall attempt, in some sort, to answer. From the period of tentative, of trial, sometimes of surprise, has succeeded a period of certainty and of knowledge of results. Station engineers, consulting engineers, contracting engineers, upon whom the chief work of organising and running enterprises of great pith and moment depends, now know where they stand and in what direction to look. It will therefore be interesting to glance around and make an up-to-date report upon the stations now supplying the Metropolis and other large towns in Great Britain, to see exactly in what position they now stand, their progress, their results, their hopes and fears. Useful, too, in a way every practical man will understand, will be to see exactly how their organisation, their machinery are working—what are found good, and in what directions modifications are or might be made; what details have stood the test of time, or what have been discarded. And the great question of cost of generation—how is this supervised and dealt with on a commercial basis, what results are achieved, and what may be looked for in the future? In giving a description of the present status of the great electric light companies now at work from this point of view we shall, we think, be giving not only a useful comparison of work accomplished, but an interesting summary, profitable alike to practising engineers, to students, and to intending customers—be they private or public corporations.

Our purpose is briefly to deal with the history during the last year or two of these undertakings, to describe with some technical detail the plant and working of the stations, and to deal in general with the cost of generation and distribution of electrical current to the public. We shall begin with the Westminster Electric Supply Corporation, a company interesting and important alike for the central position it occupies, for the fact that it supplies our Houses of Parliament, and for the care with which every detail of working and management has been thought out under the guidance of their able chief engineer, Prof. Alexander B. W. Kennedy, F.R.S., whose devotion to the cause of electrical engineering is indefatigable.

THE WESTMINSTER COMPANY—GENERAL.

The Westminster Electric Supply Corporation, Limited, was registered on 30th June, 1888, with a capital of £100,000 in 20,000 £5 shares. This has been subsequently increased to £300,000 in 60,000 £5 shares, which are all fully paid up. These shares are now officially quoted at 5¾, but are held tightly, and any transfers that are made at this moment are made at but little under 6, which sufficiently indicates the status of the company at the present date. In addition to the ordinary share capital the company have issued debentures to the extent of £29,400 at 5 per cent., and owing to the advance of the company the next issue of £40,600 of debentures was made at 4½ per cent. (making a total of £70,000), and it is quite expected that any further issue will be able to be made at the very moderate price of 4 per cent.

The Westminster Company obtained their provisional order in 1889, and commenced supply from a temporary station in Dacre-street, Westminster, on July 1, 1891. Their standard charge at the commencement was at 8d. per Board of Trade unit.

The company then obtained permanent sites, and erected three stations: (1) at Millbank-street, Westminster; (2) at Eccleston-place, Belgravia; (3) at Davies street, Mayfair. Their chief office was for some time at Victoria-mansions, but this has now been removed to their Eccleston place station, where the staff occupy a fine set of specially-built offices adjoining the central station.

The charge for current was reduced on July 1, 1892, to 7d. per unit, and still further on April 1, 1893, to 6d. per unit for electric lighting, while current for motor purposes is being supplied at 5d. per unit.

The system employed throughout is the low-tension continuous-current system, at 100 volts, with three-wire distribution, using accumulators in conjunction with direct supply. All the three networks are connected together in parallel, though means are adopted for working separately when desired, or for one station to take the load or part of the load of any other station if necessary.

In February last the total amount of roadway laid with mains was 33 miles, making 130 miles of ways, into which upwards of 97 miles of copper strip and cable had been drawn.

The current being supplied at the various dates as below was as follows, in the equivalent of 8-c.p. lamps:

Dec. 31, 1891,	current equivalent to	62,820 8-c.p. lamps.
Dec. 31, 1892,	" "	98,686 "
July 31, 1893,	" "	114,294 "

On the latter date there were applications in hand for about 6,000 more 8-c.p. lamps, making, therefore, a total of 120,000 8-c.p. lamps.

The company have lately been endeavouring to get their customers to take current for electric motors, and already have met with very satisfactory responses, and this department of supply seems likely to grow to considerable dimensions. Already several electric lifts have been installed, in addition to a fair number of motors for ventilating and driving purposes. These motors in every case are supplied direct from the lighting mains. At first there was some difficulty owing to the large and sudden increase or decrease in current taken; but a rule has been made that in every case a starting resistance must be inserted, and they have succeeded in obviating all difficulty from fluctuation of voltage. The same observation applies to the supply of large arc lamps for photographing, of which several are now supplied.

The company have machinery capable of supplying an equivalent to 130,000 8-c.p. lamps. With additional plant, for which room has been left, this can easily be extended to supply 170,000 lamps, while with the addition and extension of the premises on the present sites plant equal to the supply of 600,000 such lamps can be installed. It is not thought that an addition to the number of stations will be necessary to cover the district over which the company have powers of supply.

The Westminster Company paid their first dividend as an interim dividend of 3 per cent. on June 30, 1892, for the half-year. On December 31, 1892, they paid an additional dividend of 4 per cent., making a total dividend for the year of 3½ per cent. per annum. An interim dividend has now been declared for the half-year ending June 30, 1893, of 3 per cent.

Almost from the commencement the company supplied the electric light for the Houses of Parliament. This was a partial installation, and it has been further increased by a large number of lights in both Houses, and a further increase in the number of lights will shortly be made. They have made provision for lighting the Foreign Office, and have also been requested to make provision for the supply of other large Government departments.

Among other large buildings and institutions that the company supply may be mentioned Buckingham Palace, the Royal Institution, the Zoological Institution, the Royal Institute of British Architects, the three engineering institutions (the Institution of Civil Engineers, of Mechanical Engineers, and our own Institution of Electrical Engineers). There are also the Westminster Town Hall, the Middlesex

County Council, the Cape Government Office, the New Zealand Government Office, and the General Medical Council. Of hotels there are the Westminster Palace, the Windsor, Albemarle, Berkeley, Belgravia, Harvey's, and others. Of clubs in the district, they supply the Junior Constitutional, Devonshire, Brooks's, the New University, Badminton, Wellington, Cavalry, Piccadilly Club, Albemarle Club, the Arts Club, etc. Several large photgraphers are also supplied, such as W. and D. Downey, Mayall's, A. J. Langton.

With regard to the supply of large premises, the Westminster make a considerable reduction in price on large supply. It is interesting to note here that the Westminster Corporation were the first company to make a reduction in price to their customers of this kind. The following is their scale of rebates:

Units.		Rebate per cent.	Approximate equivalent in pence per unit.
Under	3,000		6d
Over	3,000	1	—
"	4,000	2	—
"	5,100	3	—
"	6,300	4	5¾d.
"	7,700	5	—
"	9,300	6	—
"	11,200	7	—
"	13,400	8	5½d.
"	15,800	9	—
"	18,500	10	—
"	21,700	11	—
"	25,400	12	5¼d.
"	30,000	13	—
"	36,200	14	—
"	45,000	15	—
"	60,000	16	5d.

Motors are supplied by separate meters at the price of 5d. per unit. The following list of motors already supplied will be found interesting:

Lifts, passenger and service	5
Hairdressing	3
Bottle washing	1
Ventilation	2
Hydraulic pump	1
Circular saw	2
Organ-blowing	2
Dentist drills	6
Lathes, etc.	3
Refrigerator machine	1
Driving testing dynamo	1

Besides this there are supplied:

Cautery instruments	4
Supply for surgery	2
Electric launch station	1
Omnibus charging station (Bristöl Company)	1
Accumulator charging (Lithanode Company)	1

The price for charging accumulators is 5d. per unit. Current for cooking and heating apparatus is also supplied, but not as yet to any very large extent. An exhibition of electric cooking utensils is kept on view, as well as samples of motors, fans, radiators, etc., at the company's offices at Eccleston-place, and these, being shown in action, have been instrumental in inducing several consumers to use electric energy for purposes other than lighting.

The following is a list of the officials of the Westminster Electric Light Corporation:

Directors.—Right Hon. Lord Suffield, K.C.B. (chairman), Sir Douglas Galton, K.C.B., Edmund Boulnois, Esq., M.P., W. Hayes Fisher, Esq., M.P., J. Browne Martin, Esq., J. Heslop Powell, Esq., R. W. Wallace, Esq.

Officers.—Captain Edmund Bax, manager; Prof. A. B. W. Kennedy, engineer-in-chief; Frank Iago, Esq., secretary.

Engineers.—Davies-street: first, Ll. Foster; second, H. H. S. Baker; third, G. Horley; 18 men and office boy. Eccleston-place: first, C. O. Grimshaw, second, F. A. Nixon; third, W. Thompson; 19 men and office boy. Millbank-street: first, F. Newington; second, W. Robinson; third, G. Clarke; 19 men and charwomen.

Mains Department.—E. W. Monkhouse, superintendent of mains; C. Monson, assistant superintendent of mains; J. Turner, clerk; and 33 workmen.

Meter Department (Outside).—L. H. Hordern, superintendent of meters; J. E. Dane, chief inspector; C. G. King, clerk; H. J. White, clerk; Corry, Allard, and Day, meter readers; and three men and one boy.

Meter Department (Inside).—J. W. Jones, chief; A. Mears, clockmaker; W. J. Dawson, assistant clockmaker; also one man and two boys. In this department all meters are tested, calibrated, repaired, etc., and they are delivered to the outside meter department, who fix them in consumers' houses, calibrate them *in situ*, take readings, etc.

Office.—H. Booth, collector; S. H. Stanley, assistant collector; W. A. Pearman, bookkeeper; A. Farthing, transfer clerk; A. E. Upsdell, correspondence, etc.; P. Porter, general, C. Frost, office, C. Weiss, draughtsman, Captain Webb, canvasser.

THE COST OF ENERGY FOR ELECTRIC TRAMWAYS.

BY FRANK B. LEA.

It is considered by many of those who should be in a position to judge accurately the probable course of events, that some reasonable progress in the development of electric traction will soon be made in this country; if for no other reason, this is thought likely because a Joint Parliamentary Committee has put an end to some of the difficulties in the road by drafting model clauses of an equitable nature—protecting all the interests involved—for insertion in tramway and other such measures brought before Parliament. Although such progress must from its very nature be somewhat slow, no great regret need be felt at this, for if we are to take fresh steps in a new direction, they cannot well be too sure. What is vulgarly called a "boom" has, as a rule, but one ending, and the spelling of it is "panic." A steady growth and development is not only cheaper in the end, but offers greater advantages in every way: the experience gained is more reliable than when a mad rush takes place, whilst public confidence is secured with far more certainty. It is most sincerely to be hoped that any progress which may occur in electric traction generally will be characterised by such a steady growth as can alone make of it an enduring and profitable business.

One particularly important point which will require some consideration at the hands of all electric railway or tramway engineers involves the question of stationary power plant, and the cheapest method of obtaining a constant supply of electric energy. The question becomes practically the following: Is it more economical for an electric line to instal its own stationary generating plant, or may it with greater advantage obtain a supply of energy from the nearest continuous-current electric lighting station? assuming, of course, that such may be available—by no means a remote contingency nowadays. So far as electric lighting interests are concerned, the utilisation of their generating plant during the day is of course a most desirable object to attain; every electrical engineer is familiar with the 6 to 10 p.m. "peak" in the output diagram of a lighting station, but the problem of equalising the load throughout the 24 hours in order to have a continuous peak, or rather "tableland," and thus run the station at maximum output, remains as yet practically unsolved. If the average load in such a station were anything like 50 per cent. of the maximum, the selling price of surplus electric energy could without doubt be materially reduced below the 3d. per unit at which it is now offered for such purposes as the working of electric motors, etc., during the day.

Electric lighting authorities in general—whenever a suitable supply is close at hand—would therefore appear likely to show a most favourable consideration of any proposals to sell current for an electric tramway; although the demands from both lighting and power circuits to some extent overlap, say, between the hours of 6 and 10 yet there is usually an ample reserve at all

allow of slight overloading for this period. Such a course is obviously more economical than the running of large machinery during the daylight hours on a small load, or no load at all. Much depends in this connection upon the sizes of unit adopted: the tendency, however, seems to be towards increasing these as much as possible, consistent with economical working

Some figures were given a year or two ago in the American technical papers relative to the cost per car mile of electric energy put into the line, in the case of tramways operated on the overhead wire or "trolley" principle, where the supply was in each case obtained from a station specially erected for the purpose, and there seems to be no reason for doubting their accuracy. The average cost upon 22 such lines was stated to be equivalent to 1·17d. per car mile, the highest being 2·9d. and the lowest ½d. The expenses included were the following: maintenance of power plant, repairs to engines and dynamos, fuel, wages, oil and waste, etc.; but a very essential feature to point out is that the number of cars operated on each line varied enormously—from three to one hundred and forty. It need hardly be said that, as a rule, with the former expenses were naturally at a maximum per car mile, and conversely. The average cost would probably apply to those roads upon which 20 cars or more were running continuously.

It is not, however, at all clear whether any account whatever has been taken of charges which ought, in all fairness, to be included in such estimates, as part of the cost per car mile not incurred on the alternative plan; a sinking fund should be allowed for, and the subject of depreciation is hardly settled by vaguely referring to "maintenance of power plant." Take, for instance, the case of a road upon which 20 cars are kept running over a length of, say, a dozen miles. The capital outlay required for buildings, generating plant, and machinery, etc., would be little, if any, less than £18,000, and a fair amount for depreciation and amortisation of this sum ought to be included.

Returning now to the plan of purchasing electric energy for traction purposes from an electric lighting station, it is obvious that some considerable difficulty must arise in obtaining the average cost, and even in estimating a maximum or minimum. The figures will vary for each individual road, perhaps more especially in proportion to the average number of cars at work, but the questions of speed, length of line, gradient, and loads—both dead and paying weights—also influence the cost per car mile very considerably. The average horse-power required from the supply station or electric mains per car on the line varies, of course, from zero, if the car is supposed to run down hill, to 3 or so when on the level, and to as much as 20 or even 30 when starting with a heavy load on an up grade. Probably 10 h.p. represents the maximum average amount required per car, taking all conditions into account, and many skilled engineers consider that this allowance is excessive.

If we assume, say, 7 h.p. per car, employed for 12 hours daily, with a total of 20 cars on the line, the horse power hours become 1,680 per diem. The car mileage will not exceed 2,000 per day at the outside, but with this allowance, and assuming the price of electric energy to be 3d. per unit, the cost per car mile works out to 1·879d.—a very favourable showing, if the figures upon which it is based are correct. Probably it is too favourable, even with the comparatively large number of cars assumed, and a sum of 2·5d. or even 3d. per car mile would more nearly represent the true expenditure.

In any case the cost of purchasing current from electric light stations for tramway lines would appear to exceed that incurred by putting down special plant for the purpose, not, however, taking into account the trouble and expense of erecting and administering it.

The other side of the question—viz., the advisability of selling whatever spare power there may be in an electric tramway generating station for lighting purposes outside—opens up rather too wide a field for discussion in this place, and it may therefore be fitly taken up at some other time. Meanwhile let us hope that sufficient work may soon be *done to verify or contradict the figures* given herein.

A NEW SHUNT ARC LAMP.*

The fundamental idea of the type of lamp illustrated consists in the provision in shunt to the terminals of the lamp of an electromagnet with a movable armature in connection with a check contrivance, as a clock train, and which forms the arc and also regulates the position of the carbons. Lamps constructed on this principle, although the electromagnetic disposition is the most simple, have certain defects in construction which require special remedies. The first defect lies in the fact that the armature, *b*, Fig. 1, which during the burning of the lamp takes up the position of equilibrium between magnetic attraction and pulling power of the spring, *c* (this position being necessitated by the terminal pressure), is partly dependent upon the weight of the carbons suspended from the holders. As this unequal weight under the thicker upper carbon is continually being altered by the burning of the carbons, the armature must also alter its position, and the tension of the arc change correspondingly with the burning, and certainly increase if the swinging axis of the armature lever falls together with the revolving axis of the chain pulley.

A second defect is based on the known fact that an electromagnet, through heating of the coils, has a higher electrical resistance, and therefore with a constant terminal

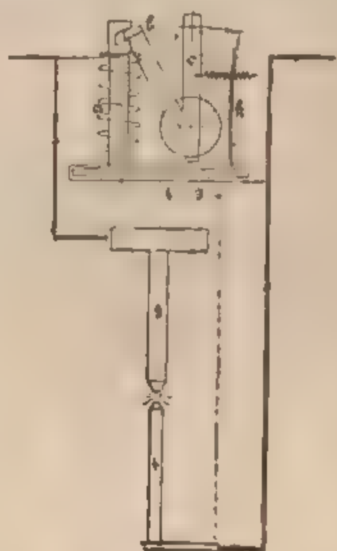


FIG. 1.

pressure its attractive power is weakened. It therefore requires a higher tension than the initial pressure to let the armature play on the same limits with warm coils as when the latter are cold. Nearly all shunt arc lamps of this type are subject to this defect of an increase in the pressure of the arc in consequence of the heating of the coils.

The increase in the pressure through a diminution in the weight of the carbons has in the before-mentioned type been compensated by a lever arrangement, as shown in Fig. 2. As will be seen, the armature lever is connected fast to the clockwork, and the whole system swings round the turning point of the armature lever, whereby the chain pulley must act to the armature lever as an unequal-armed lever in the ratio of 4 to 9. This ratio corresponds to the relation of weight of the carbons to one another, and thus the products from lever length and weight of carbons are equal. As the carbons are now of equal length, and burn equally, it is clear that the equilibrium of the armature lever load during the whole period of burning cannot be interrupted.

The increased pressure of the arc due to the heating of the coils is balanced by a compensation band, *k*. This consists of two pieces of metal soldered together, as, for instance, steel and zinc, and which in a normally cool condition are stretched straight out, and when warm they become curved. As the lower end of this band is firmly fixed by screws, the

* Abstracted from the *Elektrotechnische Zeitschrift*.

upper end, which carries the striking tongue, *g*, must make a certain stroke. The length of the stroke corresponds as far as possible exactly with the recedence of the armature, *b* (caused by the heating of the coils) from its starting point, with cold coils, so that the relative position of the armature remains unchanged, and therefore the pressure of the arc does not vary.

We will now proceed to explain the method of construction. The magnet, *a*, Fig. 2, attracts its armature into a visible slit in the pole pieces away from the spring, *e*. Over the pulley, *d*, of the clockwork, *c*, is laid a chain which carries both movable carbon-holders. If the lamp is put in circuit before the carbons are a specified distance apart, the armature, *b*, lies entirely in the slit, and the stoppage of the clock train by means of the wheel, *f*, and striking tongue, *g*, is removed, so that the carbons in consequence of the greater weight of the upper carbon-holder approach one another. On the carbons coming into contact the magnet, *a*, is suddenly without current, and it lets the armature travel so that the arc is formed, as the chain

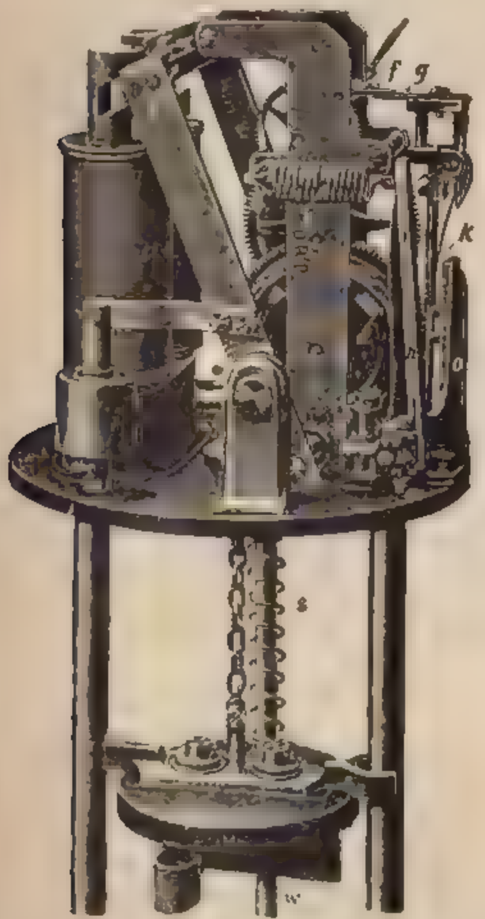


FIG. 2.

wheel, *d*, participates in the movement of the armature lever, and the armature takes up the position of equilibrium between magnetic attraction and pulling power of the spring, *e*.

The approach of the carbons is regulated in such a manner that the armature, *b*, at maximum pressure of the arc is drawn so far into the slot that the wheel, *f*, lifts itself off the striking tongue, *g*, whereby the clock train permits of a slow approach of the carbons, which at the next minute is checked by the stoppage of the flywheel. The regulation of the pressure of the arc is effected by the spring, *e*, which by means of the lever, *h*, is placed in position through the screw, *m*. The current is led to the upper carbon-holder by a movable bare copper spiral, *s*, which is prevented from lateral motion by the rod, *w*.

The chief advantages claimed for this lamp for practical use are great simplicity of regulating the current to a certain pressure. The lamps work well at low pressure, as, for instance, 100 volts, and they are almost independent of the current strength. The lamps are made by Messrs. Korting and Mathiesen, of Leipzig.

RELATIVE COST OF CONDUCTORS WITH DIFFERENT SYSTEMS OF ELECTRIC POWER TRANSMISSION.*

BY GISBERT KAPP.

It is just 20 years ago that the reversibility of the dynamo-electric machine was discovered, and with it the electrical transmission of electrical power. The machines then and until recently employed were of the continuous-current type, but within the last few years transmission of power by some form of alternating current apparatus has come into use, chiefly because it enables us to carry power to a greater distance with a moderate rate, and, therefore, moderate cost of conductors. The reason for this economy lies in the fact that owing to the scheme of commutators, and the facility and certainty with which alternating-current transformers can be insulated, the effective pressure at which the current is transmitted is much greater with alternating than with continuous currents. To put it in another way, with continuous-current plant the voltage is limited by the difficulty of insulating the generating and receiving machinery. With alternating-current plant there is no necessity of high insulation of generators or motors, but only of the step-up and step-down transformers, and since this type of apparatus can, by the use of oil or other means, be insulated to any desired extent, it is the difficulty of insulating the line rather than the machinery which limits the voltage that can be safely employed. In comparing the various systems of transmission as regards economy of material we must put all on the same basis by so designing the plant that there shall be in each case the same stress on the insulation, or, in other words, that the difference of potential between any two points in the circuit, or between any point and earth, shall not exceed the predetermined limit. The systems of transmission which have as yet been practically employed, and which alone even claim our attention here, are the following: single-phase alternating current transmitted by two wires; double-phase alternating current transmitted by four wires; double-phase transmitted by three wires; three-phase alternating current transmitted by three wires; continuous current transmitted by two wires. The last case, although practically impossible for extra high pressures, is here included because it gives us a financial standard of comparison for the other four methods of transmission. It is well known that in every circuit the different parts of which are equally well or equally badly insulated the electrical centre of gravity remains always at zero potential, and it follows from these reasons that if the circuit carry an alternating current, the absolute potential of any point undergoes cyclical change, bringing it in turn above and below the potential of the earth by an equal amount. Thus, in a circuit carrying 10,000 effective volts, the greatest potential difference between two points will be 14,000 volts, and the greatest possible value of the absolute potential will be 7,000 volts, positive or negative. The insulation to earth will therefore be put under a stress not exceeding 7,000 volts; if, however, one point on the line were earthed, the stress at every point would immediately rise to 14,000 volts. We can now compare the continuous and single-phase alternating current as regards weight of copper required for the line, assuming in both cases the same total power and the same efficiency of transmission. Let us fix the greatest permissible stress at 7,000 volts from the earth, then it will be immediately clear that the effective voltage of transmission in the case of the alternating current is 10,000 volts, and in the case of continuous current 14,000 volts, and since the weight of copper for equally efficiency conditions varies inversely as the square of the pressure, it follows that the transmission of power with alternating current requires twice as much copper as continuous. With two-phase currents and completely duplicated circuits—*i.e.*, four wires in a line—the same holds good, as will be obvious on considering that each circuit has half the power; but how does the case stand if we bunch two of the wires? In this case we have half the current in each of the external wires, and about 70 per cent. of the current in the middle wires, resulting apparently in a saving of copper.

* Paper read before the British Association.

is a fallacy; not only is there no saving of copper, but we require actually more copper than with a single-phase system, on the four-wire double-phase system. The reason being that if we tie two of the terminals together we forcibly displace the electrical centre of gravity of each circuit, causing the potential of the other terminals to vary between wide limits. To keep the stress on the insulation down to given limit, we must therefore lower the voltage of each circuit, and this means that we must use more copper in the line. Similar investigations made for the three-phase system shows that the effective voltage in each circuit must be lower than with a continuous current, but may be higher than with a single-phase alternating current. I shall not occupy time by giving the mathematical investigations of the various cases previously mentioned, but will simply state the practical result. If we put all the systems on the same footing as regards efficiency of safety of insulation we find the following: If for the transmission of a certain power over a given distance by continuous current, 100 tons of copper are required for the line, then the single phase alternating and the two-phase four-wire system will require 200 tons, the two-phase three-wire system will require 290 tons, and the three-phase three-wire system only 150 tons. As far as the line is concerned, there is thus a distinct advantage in the employment of the three-phase system.

ON A NEW FORM OF VARIABLE POWER GEAR FOR ELECTRIC RAILWAYS AND TRAMWAYS.*

BY W. WORBY BEAUMONT, M.INST.C.E.

It is a matter of great importance on electrical railways and tramways that the maximum steam-engine power at work in the generating station should be as little above the mean load as possible.

It is found on electrical railways now at work that there is a great waste of power, and therefore of fuel, in consequence of the large consumption of current in getting the trains into motion by motors attached directly to the axles. On the South London Railway it is found that the power employed electrically in overcoming the inertia of the train is from 25 to 50 and 60 per cent. greater than that required to keep the train going.

Mr. J. H. Greathead, M.I.C.E., the engineer of this railway, has shown that if this could be avoided, from 20 to 30 per cent. of the engine power, which must under present conditions be kept running, might be shut down. The author showed this by diagrams representing the variation in the consumption of power in the working of this railway, as given by Mr. Greathead.†

For several reasons the employment of geared locomotives is undesirable on railways, although single-reduction gearing is most generally adopted for tramways, and probably will remain best for that purpose. The noise made by high-speed gearing, and the wear, are both objectionable, otherwise a geared locomotive offers the means of overcoming to some extent the losses referred to.

In the paper the author showed how an intermediate course can be adopted which will remove the loss of power at the generating station. The electric motor is placed directly on the driving-axle, but is reduced in size and power to more nearly that of the mean horse-power required on the road. This, for the greater part of the journey of a train from station to station, drives the axle upon which it is placed, at its own speed, just as those do which are now upon the South London Railway. The motor is, however, on a hollow spindle, which drives the axle when starting a train, through the medium of a compact double clutch containing one pair of epicycloidal reducing wheels. The clutches are operated by electromagnets in one case and by fluid pressure in another.

Power Gearing for Electric Locomotives.—In Figs. 1 and 2 the gearing is shown as operated by fluid pressure, and arranged as for a locomotive for direct driving. On the axle, C A, is fixed a disc, B, containing an annular cylinder, or rather chamber, in which is an annular piston, P, which, by admission of oil under pressure, or air from the continuous-brake cylinders, is caused to press, when necessary, against gripping ring, C. On the end of the motor shaft, A, is fixed an excentric, D, which gives a gyrating motion to the toothed ring, E. This correspondingly gives motion at a slow rate to the gear ring, F, which is fixed to the disc, B. Upon a projecting part of the internal gear ring is a bridle with an arm, E¹. This arm is free to slide in a bridle, O, pivoted in a ring, G. The ring G is either permitted to run free or is held fast by parts which constitute a brake clutch, of which only the ring, H, and levers, L, are seen.

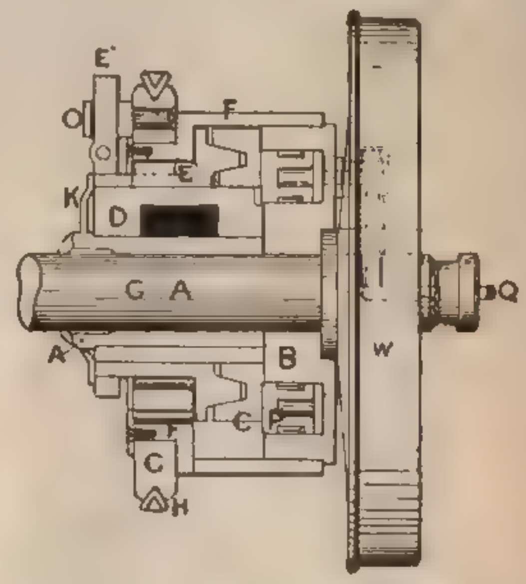


FIG. 1.

When it is desired to start a train, the ring G is held fast by this apparatus, and O becomes a fulcrum, about which E¹, with the ring E, gyrates. The locomotive axle is then driven by the wheel or ring F at one-fifth the speed of the motor, or a power ratio of 5 to 1. This is required for a few seconds at each start. The inertia of rest of the train having been overcome, the ring G is set free, and fluid under pressure admitted at Q, thus pressing

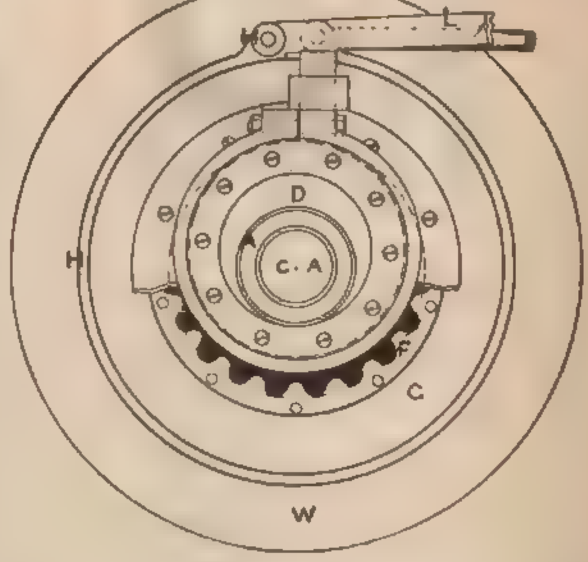


FIG. 2.

the ring C upon E. This fixes the whole of the working parts of the gear, and couples the motor shaft and locomotive axle, so that the latter is direct driven. The motor can thus run idle, driving nothing, or it may drive the axle at one-fifth of its speed or at its own speed. When running at normal speed, the whole of the gear described runs as one solid piece, and only works for starting a train

* Paper read before the British Association.
† *Proceedings, Institution of Civil Engineers*, vol. cxii.

or getting up hill. A breakdown would leave the locomotive in the condition of a gearless engine.

The arrangement of the gearing for tramcars when single-reduction gear is employed, is shown in Figs. 3 and 4. In this the motor shaft, A, carries a disc electromagnet, B, which has, as an armature, a disc, C, on the boss of the pinion, J, which gears into the wheel, J^1, on the car axle,

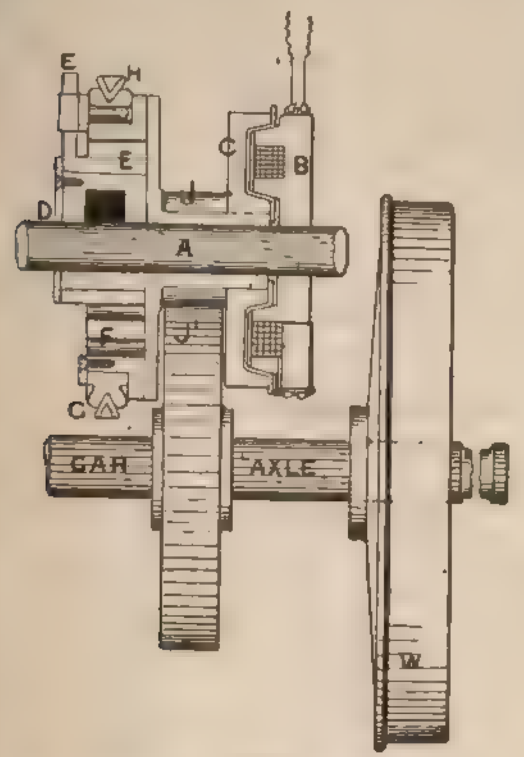


Fig. 3.

the ratio being 4 to 1. The epicycloidal gearing is very similar to that in Figs. 1 and 2, and gives, as shown, a speed ratio of 5 to 1. With this arrangement a motor of 15 h.p. would be ample for any tramcar instead

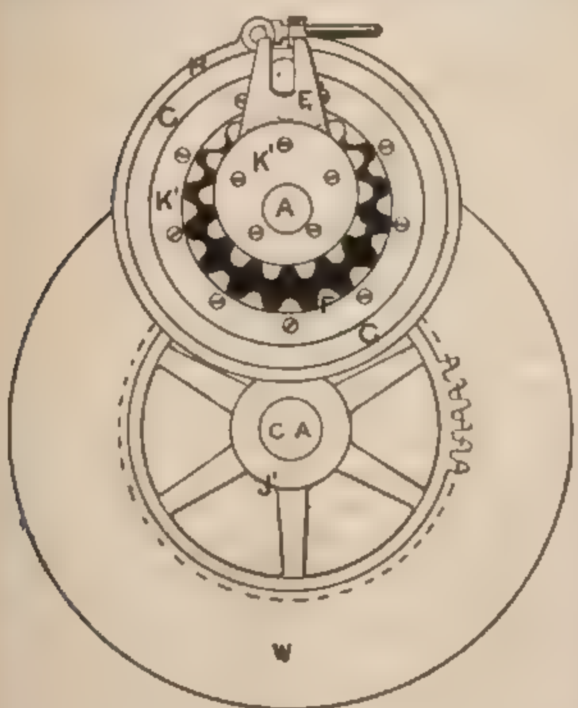


Fig. 4.

of the 30 h.p. now used. The motor in starting may run idle, or may drive the car axle through the epicycloidal gear and single-reduction gear at, say, a ratio of 20 to 1, or by passing a current into the coils and by energising the magnet, B, the whole apparatus runs solid on the motor shaft, the gear ratio then being that of the single-reduction gear of 4 to 1.

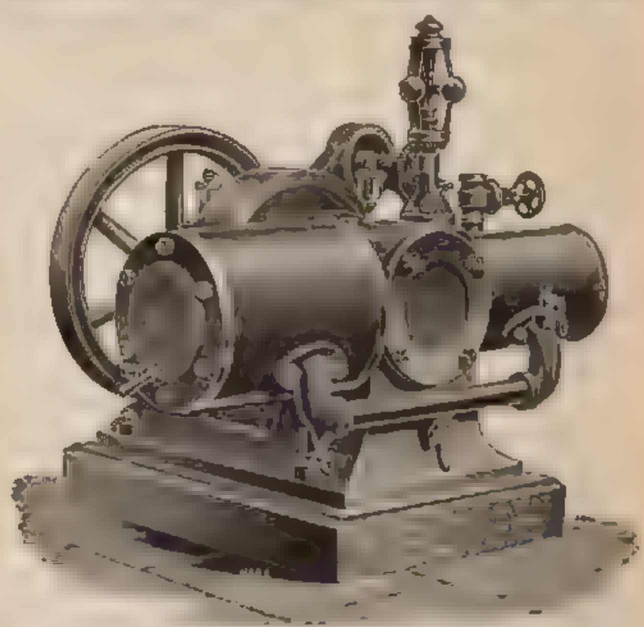
TRADE NOTES AND NOVELTIES.

THE "WILLIAMS" VALVELESS HIGH-SPEED ENGINE.

In the accompanying illustration is shown a new and novel type of high-speed engine which is on view for the first time at the Laundry Exhibition, which closes to-morrow at the Royal Agricultural Hall, Islington. Our illustration represents a 5-h.p. single-acting horizontal compound engine, the high-pressure cylinder of which is 4½in. diameter, the low-pressure cylinder being 6 11-16in. + 1 32in., and the stroke 4in. We are informed that on a trial with the engine running at a speed of 420 revolutions per minute, with a boiler pressure of 120lb., the power developed was as follows:

Indicated horse-power, high-pressure cylinder...	3·084
Indicated horse-power, low-pressure cylinder...	2·152
Total indicated horse-power	5·236

While on the brake it gave 4 9 h.p., the mechanical efficiency of the engine in terms of $\frac{\text{B.H.P.}}{\text{I.H.P.}}$ 100 = 93·583 per cent. The consumption of feed-water by actual weight pumped into the boiler by hand was 165·45lb. per hour; this corresponds to 31·59lb. per indicated horse power hour, and 33·765lb. per brake horse-power hour. At another trial with the same engine developing 6·24 i.h p., the consumption of feed-water was found to be as low as 30lb. per indicated horse-power hour.



These results are very satisfactory for an engine of such small power. It will be evident that the engine is economical. But this is not its only feature, as it is remarkable in respect of its simplicity of construction. The engine has only three working parts, comprising the piston, crank-shaft and crank (which are one forging), and the crank-pin bearing. The engine has no steam-chest, no slide or other valves, no valve-rods, no eccentrics, slides, slide-bars, piston-rod, connecting-rod, pins or joints, and no stuffing-boxes or packing of any kind, not even piston rings or grooves in the pistons, which latter are a perfectly steam tight working fit in their respective cylinders. The pistons act as their own steam-distribution valves, and can be arranged to cut off steam at any part of the stroke, and to work with any degree of expansion with no addition to the mechanism. The engine exhibited at the Laundry Exhibition is of the simple horizontal type, having two single acting cylinders, each 6½in. diameter by 4in stroke. It is working continuously 12 hours per day at a speed of 420 revolutions per minute, and with 80lb. initial pressure will indicate 16 h p., and is guaranteed to give 14 4 h.p. on the brake, or an efficiency of 90 per cent. Steam is supplied through 90ft. of partially covered pipe from a vertical boiler, and it exhausts through 120ft. of pipe and seven bends; notwithstanding these adverse conditions and the consequent back pressure due to the exhaust steam and water in the pipe, the engine is working at the speed above named with absolute silence and freedom from vibration. The makers state this same engine will develop 25 i.h.p. with an initial steam pressure of 115lb. per square inch. It occupies a space of 3ft. 9in. by 3ft. 3in. by 2ft. 3in. high, and weighs approximately 11cwt.

The engine, which has been invented and patented by Mr. T. H. Williams, A.M.I.C.E., is exhibited by the sole Messrs. Glover and Hobson, Albert Iron-w[illegible] road, Old Kent-road, London, S.E.

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 Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

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ONE AND NINEPENCE, SUBJECT.

It may be wondered whether any criminal—not utterly hardened—has awaited the gradual expiry of his fourteen years' sentence with greater eagerness and joyful expectation than very many of those interested in the electrical industry would appear to do for the termination, after a similar interval, of the incandescent lamp monopoly in this country. From time to time opinions respecting the influence of these patent rights upon the progress and development of electric lighting have been very freely expressed, and the most sanguine hopes formed with regard to increase of business when the market is thrown open next November for the indiscriminate manufacture and supply of incandescent lamps either to the trade or private users. It is not our province, however, to justify the policy of the Edison-Swan Company, even if this were necessary; the directors of that corporation owe a first duty to their shareholders, and therefore look upon the matter, as anyone would, purely from a business point of view, making the most of opportunities thus afforded to develop their own enterprise and strengthen its position against inevitable competitors.

Satisfaction, however, may be expected on all sides from this time forth: consumers, both present and intending, will be called upon to pay less than half the present price for the incandescent lamps which are an absolute necessity of their installations, and which hitherto have made no inconsiderable difference in the first cost and operation of such. Electrical contracting firms ought, as a consequence, no longer to be met by clients with the objection that they prefer to wait until lamps are cheaper before lighting their rooms by electricity; central stations will benefit correspondingly by increased output; and, lastly, it may be expected that the lampmakers themselves—though not enjoying the large profits hitherto possible—will continue to reap a fair harvest from the sale of reliable and efficient lamps at eighteenpence each, practically double the actual cost.

All these glowing prospects are to follow upon the action of the Edison-Swan Company in reducing—as noted elsewhere—the price of their lamps from 3s. 9d. to 1s. 9d. each, in anticipation of the expiry of their master patent in November next. It was, of course, to be expected that some such action would be taken, since no likelihood existed of the courts prolonging the life of this patent, even had they been petitioned to do so. The sole reason for adopting such a course would be to show the absence of any material profits upon or opportunity to develop the manufacture and sale of the lamps—a position hardly to be claimed by the Edison-Swan Company. In order, therefore, to anticipate the influx more especially of cheap and inefficient lamps from abroad, the Edison-Swan directors have given this early notice of their intentions; and to that extent deserve full credit from the trade generally.

There are several interesting topics connected with this announcement that should at the present time receive careful attention, and comment upon them in these pages is therefore particularly *à propos.*

In the first place, it is to be remembered that although flashed carbon filament lamps may be manufactured by anyone who desires to do so, there are two reasons why the Edison-Swan Company will have an enormous advantage over all other makers, inasmuch as they are in possession of experience — both technical and general — acquired during the past decade, of a kind that time alone can give at the expenditure of no small sum of money, and they also own what are practically master patents upon the lampholders that will, of course, bring in a revenue corresponding with the increase of lamps employed, though the individual profit on these appliances is much less than has been the case with the lamps.

Each of these reasons would without doubt be sufficient in itself to secure a great part of the trade to the present makers, for obviously there is no real saving in the purchase of cheaper lamps that have a correspondingly shorter life for an equal candle-power and efficiency. In the case, for example, of an 8-c.p. lamp taking 3·5 watts per candle, it may be assumed that the normal life will be one thousand hours ; if instead of two such lamps, at 1s. 9d. each, three cheaper ones be purchased at 1s. each (which is probably the minimum price for a lamp worth picking up), the life of each of the latter must be at least seven hundred hours to effect a saving of sixpence on the first cost. Unless and until, therefore, home or foreign makers other than the Edison-Swan Company are in an equally good position to ensure the output of reliable lamps, it is to be hoped for the sake of consumers and the credit of electrical contractors and supply firms that the reduction now made by the Edison-Swan Company will prove sufficient to secure them — apart from any other consideration — the greater part of the trade.

The question of profitably overrunning lamps is another matter altogether, which deserves extended attention in greater detail than is possible in this place. There is no doubt that in many cases it will be found of great advantage to deliberately shorten the life of lamps by overrunning them, if the extra candle-power thus given has a greater value to the consumer than the increased cost of more frequent renewals, as compared with those due to normal operation. Whether the first cost is now sufficiently reduced to allow of this being extensively done, depends entirely upon the efficiencies that are possible with the lamps—that is, whether the same quality will be maintained as before. If it could be proved in the end economical to run lamps at 2·5 watts per candle, considerable gain might result, not only to the consumer, who thereby gets more light for his money, but eventually to the supply stations also.

The electrical trade may congratulate itself upon the prospects before the industry. These are confessedly brighter now than ever they have been, and the ardent hopes so freely expressed of late years as to what might be done when lamps were cheaper, and public confidence thoroughly regained, stand now—or never—in the position of early accomplishment.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

TRANSMARINE TELEPHONY!

SIR,—In your last two issues there has been a good deal concerning long distance telephony and its results. I should like to call attention to some experiments. I was recently present at a new invention in this direction, and by which direct speaking to any part of the world can now be accomplished. By the courtesy of the inventor, Mr. Chas. Bannister, F.O.S. (a great authority on electrical matters and engineering), I shall be able to supply you with some information which will, no doubt, be very interesting to your readers and the electrical world in general.

The "transmarinephone," as the new invention is called is certainly more powerful than the present telephone, and its construction is different in many points. For instance, in speaking into the mouthpiece, which contains a number of small coils, the sound is instantly reproduced at the other end, on the same principle as a telegraph, no matter how long the distance, as the mechanism at one end causes the other to act in the same manner, thus getting a perfect articulation. The sound is thrown on a metallic kind of shutter, which acts upon a pivot opposite a number of coils, which in turn operate upon spring armatures, then pass through several magnets of the motor principle, opposite which is a number of platinum discs tipped with indiarubber. Then this is connected by cable to the ear piece of the other instrument, which contains some other electrical apparatus, and is so sensitive to sound that the beats of a man's heart can be distinctly counted at a great mileage off between the two instruments. The great thing with this invention is that it requires no relay of battery power, so that any distance of sea may be crossed ; but I may mention that the batteries used are of particular construction.

I was given to understand that a company will be formed for the purpose of using the instruments between London and New York, Australia, India, etc., which will no doubt be a great boon to merchants trading with the above parts to be able to speak from their London office to that situated abroad. Later on no doubt I shall be able to furnish you with more particulars on this interesting subject.—Yours, etc.,

F. L. CRAMER,
Consulting Engineer.

Regent's Park, N.W., September 16, 1893.

[We insert the above letter with a purpose. In it we have a hint as to company formation. No doubt it is easier to form a company for growing marigolds in the moon than for some legitimate operations—and possibly the marigold farm would be as remunerative to the shareholders as this transmarine telephonic company, even with the use of Mr. Bannister's invention. We—all journalists do like to pretend we know the great authorities on our special subjects : hence our not knowing how far Mr. Bannister may really claim an authoritative voice must be put down to our ignorance rather than to his modesty in keeping so long out of our sight. One word to would be inventors—try to understand the problem to be solved before attempting the solution.—ED. *E. E.*].

ON A PIEZO-ELECTRIC PILE.*

BY LORD KELVIN.

The application of pressure to a voltaic pile, dry or wet, has been suggested as an illustration of the piezo-electric properties of crystals, but no very satisfactory results have hitherto been obtained, whether by experiment or by theorectical considerations, so far as I know. Whatever effects of pressure have been observed have depended upon complex actions on the moist or semi moist substances between the metals and electrolytic or semi-electrolytic and semi-metallic conductances of the substances. Clearing away everything but air from between the opposed metallic sur-

* Abstract of paper read before the British Association.

faces of different quality, I have made a piezo-electric pile, which accompanies this communication. It consists of 24 double plates, each eight centimetres square, of zinc and copper soldered together, zinc on one side and copper on the other. Half a square centimetre is cut from each corner of each zinc plate, so that the copper square is left uncovered by the zinc at each of its four corners. Thus each plate presents on one side an uninterrupted copper surface, and on the other side a zinc surface, except the four uncovered half square centimetres of copper. A pile of these plates is made, resting one over the other on four small pieces of indiarubber at the four copper corners. The air space between the opposed zinc and copper surfaces may be of any thickness from half a millimetre to three or four millimetres. Care must be taken that there are no minute shreds of fibre or dust bridging the air space. In this respect so small an air-space as half a millimetre gives trouble, but with three or four millimetres no trouble is found.

The lowest and uppermost plates are connected by five wires to the two pairs of quadrants of my quadrant electrometer, and it is generally convenient to allow the lowest to lie uninsulated on an ordinary table, and to connect it metallically with the outer case of the electrometer.

To make an experiment—(1) connect the two fine wires metallically, and let the electrometer needle settle to its metallic zero.

(2) Break the connection between the two fine wires, and let a weight of a few decigrammes or kilogrammes fall from the height of a few millimetres above the upper plate and rest on this plate. A startlingly great deflection of the electrometer needle is produced. The insulation of the indiarubber supports and of the quadrants in the electrometer ought to be so good as to allow the needle to come to rest, and the steady deflection to be observed, before there is any considerable loss. If, for example, the plates are placed with their zinc faces up, the application of the weight causes positive electricity to come from the lower face of the uppermost plate, and to deposit itself over the upper surface of plate and weight and on the electrode and pair of quadrants connected with it.

ON THE PUBLICATION OF SCIENTIFIC PAPERS.*

BY A. B. BASSET, M.A., F.R.S.

Two suggestions have been made with regard to the publication of scientific papers—first, that all papers of importance should be published in a central organ; secondly, that a digest containing an abstract of such papers should from time to time be published.

I do not think the first scheme could be carried out so as to serve any useful purpose; for although it might suit the requirements of a few juvenile societies, it is unlikely that societies of position and standing, which have ample funds at their command for the publication of their *Proceedings* and *Transactions*, would consent to sink their individuality by giving up the publication of papers communicated to them. Moreover, as many societies derive a considerable portion of their income from the sale of their *Proceedings*, it would be impossible for them to allow the concurrent publication of papers in the central organ, as this might seriously diminish their revenue.

The importance of distributing copies of papers in quarters where they are likely to be read has been alluded to in *Nature* by more than one correspondent. In order to do this effectively, it is necessary that the author should receive a certain number of gratuitous copies. These are supplied by most scientific societies, and also by many of the American and foreign scientific journals. On the other hand, the *Philosophical Magazine* refuses to present authors with any gratuitous copies, but makes them pay for any that they require. The question therefore arises as to whether the proposed "central organ" is going to conduct its business on the principle embodied in the Latin maxim, "Do ut des, do ut facias, facio ut des, facio ut facias," or whether it intends to follow the example of the *Philosophical Magazine*, and try to get all it can without giving anything in return.

It appears to me most improbable that important and prosperous societies like the Cambridge Philosophical and the London Mathematical (to say nothing of the Royal) would lend a hand in promoting the scheme of a central organ; and in that event the scheme could not possibly be successful unless it were able to offer far greater advantages and attractions to authors than the societies do.

The only feasible scheme seems to be the publication of a digest of papers by the co-operation of the various scientific societies; and, if thought desirable, papers published in foreign countries might also be included. In order to prepare the way for such a digest, I should strongly recommend that in future all societies should follow the example of the Incorporated Society for Law Reporting, and require authors to append a headnote to their papers briefly setting forth the object of the investigation. Every three or four years the titles and headnotes of all papers relating to each separate branch of science should be copied out and arranged in proper order, and a series of digests of each separate branch of science should be published. Mathematicians would thus be enabled to purchase the mathematical digests, and chemists the chemical ones. They would thereby be in a position to find out at a glance what papers have been published on their own special subjects during that period. These digests would do for science what the digests of law cases have done for the legal profession. Thirty years' experience has shown that this scheme would work well in practice, and as many country solicitors take in the "Law Reports," any member of the British Association who desires further information can easily obtain it by applying to one of the leading firms in Nottingham.

To develop an existing periodical which is a well-known and paying concern is often more successful than to start an entirely new one; and as many authors who contribute papers to societies send abstracts of them to *Nature*, it might be worth while considering whether an arrangement could not be made with the proprietors of *Nature* by which a supplemental number could be issued, say, once a quarter, containing a digest of the most important papers published in the United Kingdom during that period. The abstracts, with possibly a little pruning, and also the type used in setting them up, would be available, and the cost of compiling the supplemental number would have to be met by a small extra charge for it.

A committee of members of the British Association might be formed with advantage for discussing this matter, and drawing up a report embodying the recommendations at which they arrive. A copy of the report should then be sent as soon as practicable, without waiting for the meeting next year, to the presidents of the principal scientific societies, in order that it may be laid before their respective governing bodies. Each of the societies which are concerned with free and applied mathematics and approve of united action could then appoint a delegate to discuss further proceedings with regard to their own particular subjects, and the same could be done by societies connected with other branches of science.

* Abstract of paper read before the British Association.

NOTE ON THE UTILISATION OF WASTE WATER POWER BY ELECTRICITY.*

BY ALBION T. SNELL.

On the Continent water power is extensively used for driving electric plants, but in Great Britain, for a similar purpose, power is usually derived from the combustion of coal. This difference in practice is partly the result, no doubt, of the relative supply of water power in the neighbourhood of places where electric plants would prove commercially profitable; but it is also largely due to the relative cost of fuel. We do not possess abundant natural sources of water power in or near our large manufacturing districts, and even if we did it is not probable that with coal at the average price of the last 10 years water power would prove much cheaper when the capital invested, interest, and cost of maintenance of the electric plant were taken into consideration. But we may with reason pause to ask two questions: Will coal at such a price be always obtainable? And do we make the most of such water power as we have and can profitably use? Let us look at the second question first. Liverpool is

* Paper read before the British Association.

supplied with water from Lake Vyrnwy, in North Wales, the total difference of head being about 500ft. There must be a considerable quantity of power in the conduit. Is any of it utilised? And if not, does the reason lie in the fact that fuel at present is so cheap? Could the Manchester Waterworks, which form a magnificent series of artificial lakes, be utilised to drive turbines and give electric energy for lighting the various towns in their vicinity? Again, the watershed behind Greenock has a fall of many hundred feet, and the water is only partly utilised to drive mills. These are only a few instances in which water power might, perhaps, be advantageously used for driving turbine-dynamos. There are, of course, numerous mountain streams which could be dammed, and thus converted into reservoirs for feeding turbines.

England has been so prosperous in the past by reason of large supplies of coal, hitherto cheap and certain, that the consumers of power have scarcely realised the necessity of any change, and can with difficulty be brought even to contemplate the utilisation of waste water power. On the Continent, however, coal is found in only a few districts, and fuel is generally dear in comparison with the prices current in Great Britain, and dearer still in relation to local wages and prices. Necessity has thus prepared Swiss, German, and Italian manufacturers for a radical innovation which gives them a cheaper power by utilising mountain streams. It is no mere figure of speech to say that natural obstacles in the way of trade competition have led to the development of this important branch of engineering on the Continent, while the very prosperity of Great Britain has tended to hinder progress in this direction. We may ask ourselves in all seriousness whether the present price of coal is likely to be maintained, and whether it would not be wise to make the most of such water power as we have by using it as an adjunct to, if not as a substitute for, coal. This is quite possible in many places, since power can be transmitted electrically at high pressure for distances of 20 miles or so with a loss not exceeding from 15 to 20 per cent. There is still much misconception on the part of the responsible advisers of manufacturers and mineral owners as to the possibilities of electricity for the transmission of power, and a lingering distrust, largely due, no doubt, to the financial booms in electric stocks some 10 years ago. But the experience gained during the last decade is gradually making itself felt, and the most conservative must admit it has given us the means of utilising natural water power in a far more efficient manner than was formerly possible.

The following brief reference to a few of the continental plants will give an idea of some of the methods of utilising water power.

Furstenfeld-Bruck.—This installation is illustrative of how a small town may be supplied by electricity for lighting and power purposes when there is water power in the neighbourhood. The power station in this case is about four and a half miles distant from the town. There are two alternators of 38 kilowatts each, driven by turbines. The alternators work in parallel at 2,600 volts, and are driven by belting from the main shaft of the turbines. The transmission conductors are two copper wires, ¼in. in diameter, carried by insulators on posts. At the distributing station there are 10 transformers, whose secondary circuits feed the distributing network at 100 volts pressure. The secondary network is above ground, there being no need to incur the extra expense of laying it in culverts. Single-phase alternate-current motors are running on this circuit. The turbines are designed for a total output of 180 h.p., equivalent to about 4,000 lamps of 8 c.p. at Furstenfeld-Bruck, and another dynamo will be added as soon as required. At present the load consists of 3,000 lamps of 8 c.p., seven arcs, and motors aggregating about 18 b.h.p. The cost of installation, including secondary cables of sufficient size to serve all the houses in the town, is about 16s. 6d. per 8-c.p. lamp at present installed; and the cost of running is estimated at 10s. per lamp, on a basis of 2,400 lamps burning at the same time. The charge for private lighting calculated for these figures is about 5½d. per unit.

Tivoli Station for the Electric Lighting of Part of Rome.—This installation is unique in many respects, and is worthy of special consideration. Its full capacity is about 2,000 e.h.p. The waterfalls of Tivoli, about 330ft. in height, and averaging 40 cubic feet per second, form the source of power. The main channel has been arranged to feed three pipes, each of which feeds three turbines of the Girard type, two of 330 h.p., and one of 50 h.p., all being coupled direct to dynamos running at 170 and 375 revolutions per minute respectively. The whole of this apparatus is underground. The large alternators give 45 amperes at 5,000 volts, and are coupled in parallel. The smaller turbines run the exciters, which are each capable of exciting three alternators. The length of the high pressure line is about 17 miles, and there are four naked conductors carried on oil insulators. The transformer station is near the Porta Pia, just outside the walls of Rome, the pressure there being about 4,000 volts, so that the drop of pressure on full load is about 20 per cent. In the station are two banks of 16 transformers each, which reduce the pressure to 2,000 volts in the secondary mains. Transformers are installed on the premises of the different consumers to reduce the 2,000 volts to the supply service of 100 volts, and there are also transformers capable of feeding 600 arc lamps for street-lighting, of which about 250 are already installed.

Lauffen-Heilbronn.—This installation is an example of power transmission by rotary or multiphase currents. The power station has four turbines of 330 h.p. each, running at 35 revolutions per minute, with 3·85 metres fall. The alternators are coupled through gearing, and each gives 4,000 amperes at 50 volts. This current is passed through the primary circuit of a step-up transformer, and is raised to a pressure of 5,000 volts. At this pressure the power is transmitted through three bare copper wires, insulated by means of oil insulators on high poles. At Heilbronn, step-down transformers reduce the pressure to 1,500 volts, and feed the distributing network on which the house transformers are placed, the final pressure at the consumer's terminals being 100 volts. Several large motors and a number of small ones are run off the circuits, the distribution of power in small units being one of the special objects of the installation. These motors are self-starting, and of very simple construction, the small ones having neither commutator nor brushes, and the larger ones not commutators, but only collecting rings and brushes to admit of adjusting the exciting current. The price charged for lighting is, approximately, 9d. per Board of Trade unit, while for motors and heating purposes the price is fixed at 4d., and there is also a sliding scale which gives reductions to large consumers. The total cost of the works is said to be, roughly, £13,000, and there are at present about 4,000 lamps of 8 c.p., 20 arc lamps, and about 20 motors. The full capacity of the plant when finished will be 19,000 lamps of 8 c.p., or their equivalent in power.

The Genoa Power Station.—At 30 kilometres from Genoa, at a height of about 550 metres above the sea-level, dams were thrown across two valleys, and thus formed two artificial lakes, having together a capacity of about 4,600,000 cubic metres, and capable of supplying 500 litres of water per second. About 140 metres of the total head were utilised for some years to drive more than 300 small hydraulic motors, and the remaining head of about 364 metres was wasted. In 1888 arrangements were made to utilise this power electrically, and in order to get the maximum effect from the head three reservoirs were constructed at different levels. The first reservoir is 130 metres below the main outlet; the second, 108 metres lower; and the third, 144 metres below the second. A power station is built at each reservoir, the available water power at each being respectively 746 h.p., 720 h.p., and 960 h.p. These are named after three of the most celebrated Italian electricians, the highest being called the Pacinotti Station, the middle one the Volta Station, and the lowest the Galvani Station. The plan of operations is to drive constant-current dynamos at these stations, and to transmit the power to a number of widely separated motors coupled in series, the pressure being varied at the stations according to the load on the circuit. The most distant motor is 30 kilometres away, and the total length of the conductors exceeds 100 kilometres. To the three stations are coupled two circuits of copper wire 9mm. in diameter, bare throughout most of its length, but insulated where it passes through villages and laid in the ground when crossing railways. The maximum pressure employed is about 8,000 volts, and the minimum about 450, which just suffices to drive the current of 47 amperes through the circuits. The dynamos are six-pole Thury machines, and are each designed for about 1,000 volts and 47 amperes. At "Galvani" there are two such dynamos self exciting and coupled directly through flexible couplings to a Girard turbine giving 150 h.p. at a maximum speed of 475 revolutions per minute. The regulation is accomplished by varying the speed of the turbine by a throttle valve worked by hand, this device, of course, being only applicable to a single unit. At the "Volta" station the generating plant consists of four groups of machines, each of one 140-h.p. turbine coupled direct to two dynamos of 1,000 volts and 47 amperes each. These eight dynamos are connected in series, and are, therefore, able to supply current at a maximum pressure of 8,000 volts. At this station the speed of the turbines is maintained constant, the regulation of pressure being effected by varying the excitation of the dynamos, which are separately excited from a machine driven by an independent turbine, the speed of which is varied by an electric regulator. These turbines were designed by Messrs. Faesch and Piccard, of Geneva, and have very sensitive governors, acting through a small motor which moves the "gate" of the regulating turbine. These keep the speed constant within about 2 per cent., even when half the load is suddenly taken off. The dynamo armatures are made as heavy as possible to assist the governing. This method of regulation, however, is found to cause trouble from insulation difficulties, and, therefore, at "Pacinotti," which was the last of the three stations to be erected, variable speed with self-excitation was again resorted to. The turbines and dynamos are here practically the same as at "Volta," excepting the arrangement for governing the current which is accomplished by a most ingenious device

each turbine is controlled by a 1-h.p. motor, worked by relay currents. The armatures have two oppositely wound circuits, each with a separate commutator, and revolve to the right or the left, according as one or other of the circuits is traversed by the relay current. A sensitive ammeter is used to make the contacts, and, since the four turbines are acted upon simultaneously by the four motors, a very quick and effective regulation results. The moving parts are made as light as possible, and thus tend to maintain the current constant, for the speed varies inversely as the torque, and therefore the automatic regulator has very little work to do. The arrangement is so sensitive that although the pressure frequently varies in a few seconds from 8,000 to 2,000 volts or less, the current is practically constant.

Cassel Plant. This installation is especially interesting as an example of the utilisation of alternate current transmission and direct-current distribution. The power station is some miles from Cassel, and consists of two turbines and two high pressure alternators. These are coupled in parallel, and the current is carried by a concentric cable to two sub-stations, in each of which there is an alternate-current motor. Each station has two continuous-current dynamos coupled rigidly, with the alternate-current motor between them. The current is supplied to consumers at 100 volts pressure on the three-wire system, and at one of the stations there is a storage battery. These plants have been instanced because they are typical of continental practice. They differ widely, both as regards size, method, and details, but they are all designed on the broad lines of utilising waste water power, and transmitting its energy electrically to towns where it can be usefully expended. Alternate currents appear to be generally selected, perhaps because they offer more advantages than direct currents for high pressures, and are generally more easily managed. And in several cases it has been deemed advisable to use a direct-current distribution with an alternate-current transmission, as at Cassel. The Genoa installation is an exceptional case, as it is simply a power plant, and the main object is to drive a number of widely-scattered motors. Yet without a closer acquaintance with the conditions and peculiarities, the writer cannot pass an opinion on the wisdom of the choice of a constant-current service. But, at any rate, much credit is due to the engineers for overcoming the difficulties in connection with maintaining the current constant. It must also be borne in mind that this plant was practically designed before the advent of a really reliable asynchronous and self-starting alternate-current motor, and it is quite possible that in the light of modern experience a similar scheme would be dealt with by an alternate-current system. The Lauffen-Heilbronn plant is at present the only important instance of a rotary-current system, and there considerable difficulty is found in balancing the load on the two circuits. In fact, however useful the multiphase currents may be for power plants pure and simple, in which a constant pressure of supply is not necessarily of primary importance, it appears to be abundantly proved that they are not suitable for lighting, as then constant pressure is absolutely necessary. A scheme for damming the River Reuse and conveying the water to a storage and distributing reservoir, having a capacity of 3,000,000 cubic feet, at Combi Garrot, is under consideration at present. The water will be distributed to the communes of Neuchâtel, Loche, and La Chaux de Fonds, and power will be distributed electrically to distances varying from 7½ to 11 miles. This is a striking instance of the possible utilisation of water power. There are scores of turbine-dynamo plants in different parts of the Continent, varying from 20 h.p. to 500 h.p., chiefly used for driving mills and lighting small towns, and even villages. For example, the plants at Chur, Schio, Lugano, Bellinzona, Reichenhall, Macerata, etc. In England there are only a few installations which derive their power from water, such as the small central station for lighting Lynmouth and Lynton, and a few private installations. A scheme, on a large scale, for electrically lighting Worcester by means of power derived from the River Severn is in hand, and will, no doubt, lead to similar plants.

The Greenside Silver Lead Mines, Patterdale, Westmoreland.—One of the most important instances of the application of water power for electric power transmission in Great Britain at present is that at the Greenside Silver-Lead Mines in Cumberland, which was designed by the writer about three years ago in conjunction with the mine manager, Mr. Borlase. These mines are among the few that find it possible to compete with foreign mines, and this is the case partly owing to a fine grade of ore which contains a large percentage of silver chiefly extracted by crystallisation, but largely because the use of electricity for winding, hauling, and pumping has decreased the cost of working. On the east slopes of Hellvelyn lies a small natural lake called the Red Tarn, and on the north-east the impounded water of Keppel Cove. Between the two waters rises the hill of Catstycam, at the base of which the two overflows join, and near to which the Greenside Silver Lead Mining and Smelting Company have erected their turbine-dynamo station. The water is led from an elevation of 1,750ft. above sea level, and flows through an open watercourse 1½ miles in length to a large reservoir, from which it is conveyed down the hillside for a distance of 360 yards in 15in. cast-iron pipes. The fall at the station is equivalent to a vertical head of 400ft., and the effective horse power is about 200. The generating station contains one of Gilkes and Co.'s vortex turbines of 100 h.p., driving a four-pole compound dynamo made by the General Electric Power and Traction Company. The house is large enough to duplicate this plant when necessary, and pipes, watercourses, etc., are already laid for this purpose. The electric current is conveyed by two bare copper conductors on poles for six furlongs, to where it enters the mine at an elevation of 1,850ft. above the sea-level. The conductors from this point are insulated and covered with lead. About three-quarters of a mile in the mine, or 1½ miles from the dynamo, a 9 h.p. series motor is employed to wind ore from a set of sinkers. Further into the mine another quarter of a mile, and down 120 yards at the bottom level, is fixed another 9-h.p. motor, working a three-throw pump, forcing the water 360ft. in height. About midway between these motors there is fixed a dynamotor, which reduces the pressure from 600 to 250 volts for working an electro-locomotive in the lowest day level of the mine, through which runs the water pumped from the 120-yards level and the whole of the water used by two hydraulic winding engines. Four horses formerly worked this level. The locomotive runs with 12 waggons, the total weight when loaded being 18 tons, and does the work of the four horses with the greatest ease. The conductors in the level are phosphor-bronze wire, and the current is fed to the locomotive by four contact pulleys. The difficulties encountered in fixing this plant and wiring the level can only be appreciated by the practical man. All main stations in the mine are lighted by incandescent lamps in series of six. The installation reflects credit on the manager, Mr. Borlase, for his enterprise in recommending the scheme to his directors, and for his perseverance in carrying it out in the face of much opposition from the miners and others interested in maintaining the old state of affairs.

The chief difficulty attending the use of water power is the irregular and sometimes intermittent character of the supply, and hence it is necessary to exercise great care in judging the suitability of water for given work. This can be obviated to a large extent by building reservoirs and regulating the output according to the power required; but when lighting forms an important part of the scheme, secondary batteries may be used most advantageously. Accumulators act not only as reservoirs, but also as regulators, storing up excess of power, and giving it out when the prime power is insufficient or the turbines are stopped. They are, therefore, especially useful on installations for combined power and light when the water power varies intermittently. And they may be made a source of economy when power is not required both by day and by night, and owing to the want of a suitable reservoir the water runs to waste during the idle period; then accumulators may be used to store the major part of this energy for electric lighting, metallurgical, or even power purposes.

It will be gathered that the writer is fully aware the small water power of Great Britain can never show results equivalent to those obtained on the Continent, yet there is undoubtedly much water power wasted here that is capable of being profitably utilised. His object is simply to call attention to the improved means of utilising water power by turbine-dynamos, and to suggest that prompt measures be taken to conserve as much power as possible by a proper attention to the building of dams and reservoirs wherever this may be feasible. And that such power should be used, if convenient, to the exclusion of coal, and, if not so, as an auxiliary power, the steam plant being used as a stand-by as much as possible. This proposal, if properly carried out, would decrease the total consumption of coal to a greater extent than is generally supposed, and would make a number of manufacturers less dependent upon it than they are to-day, even if it did not appreciably cheapen the cost of power. But in a number of favoured cases there can be no doubt that water power properly applied would considerably decrease the cost of working, allowing a proportionate gain to both producer and consumer.

Smithfield Markets.—The work of lighting the whole of the markets is approaching completion. The total capacity of plant at present being installed is 1,000 h.p., but arrangements are being made for increasing this by 50 per cent. The plant consists of four compound vertical steam engines by Davey and Paxman, and four boilers. There is also a double-cylinder horizontal engine with locomotive boiler. The dynamos, which are directly coupled to the engines, are being supplied by the Electric Construction Company, Wolverhampton. The current is supplied from Messrs. Julius Sax and Co.'s station in Charterhouse-street to the "distributing boards" in the various markets by a number of feeders of copper strip, which have a total length of over two miles, and weigh more than 28 tons. The length of wire and main cable employed makes a total of over 90 miles.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE I.

(Continued from page 251.)

GENERATION OF POWER BY STEAM—CONDITIONS OF ECONOMY AND OF WASTE.

Sir F. Bramwell, in an address to the Institution of Civil Engineers, in 1885, indicated very clearly in a convenient phrase those conditions involving waste of fuel in steam power production which are avoided by central station working. He said that we were "every day becoming more alive to the benefit where little power is required, or where considerable power is required intermittently, of deriving that power from a central source." Where little power is required the steam engine is costly, uneconomical, and inconvenient. Where great power is required intermittently both engines and boilers work in conditions extremely unfavourable to economy. It is necessary to examine into these cases more in detail, because it is the wastefulness of working in such conditions which makes central stations desirable.

Table I. gives a careful selection of the most trustworthy results of steam-engine experimental trials. In such trials it may be assumed that everything is working at its best, and that the steam and coal consumption is the smallest realisable with different engine and boiler plants. In all these trials the engines were worked with at any rate an approximation to the most economical load. It will be seen that the steam and coal consumption is less for large engines than for small engines, less for quick engines than for slow ones, and less for compound and triple engines than for simple engines. Even under favourable test trial conditions, and with an economical load, there is considerable variation in the amount of coal and steam required per horse power.

* Howard Lectures delivered before the Society of Arts.

Taking the most favourable results which can be regarded as not exceptional, it appears that in test trials, with constant and full load, the expenditure of steam and coal is about as follows:

—	Per i.h.p. hour.		Per effective h.p. hour.	
	Coal. lb.	Steam. lb.	Coal. lb.	Steam. lb.
Non-condensing engine	1·80	16·5	2·00	18·0
Condensing engine	1·50	13·5	1·75	15·8

These may be regarded as minimum values, rarely surpassed by the most efficient machinery and only reached with very good machinery in the favourable conditions of a test trial.

It is much more difficult to get the consumption of coal by engines in ordinary daily work. What is known shows that the consumption is greater than in engine trials. Some comparatively large pumping engines, which work with a steady load night and day, and which worked with 2lb. of coal per effective or pump horse power on a test trial, used 2·7lb. in ordinary working. The consumption was measured over many weeks, during which they were working 90 per cent. of the whole time. Here the consumption is 35 per cent. greater in ordinary work than in a test trial.

TABLE I.—COAL AND STEAM CONSUMPTION IN STEAM-ENGINES IN SPECIAL TRIALS.

	—	Authority.	Indicated h.p.	Boiler pressure. lbs. per sq. in.	Piston speed. Feet per minute.	Steam per i.h.p. per hour. lb.	Coal per i.h.p. per hour. lb.
NON-CONDENSING ENGINES.	*Simple.*						
	Semi-portable	Unwin	5	61	263	65	6·5
	Small Brotherhood	—	13	—	—	41	—
	Small double acting	Donkin	6	85	211	44	[5·0]
	Willans slow	Willans	9	44	200	41·8	—
	,, ,,	,,	20	112	224	30·2	—
	,, fast	,,	16	36	394	42·8	—
	,, ,,	,,	26	74	409	32·6	—
	,, ,,	,,	34	122	406	26·0	
	Reynolds-Corliss	Hill	137	97	602	23·9	2·4
	Harris	,,	134	96	606	22·0	2·2
	Wheelock	,,	140	96	608	24·9	2·5
	Compound.						
	Willans slow	Willans	10	84	122	27·0	—
	,, ,,	,,	11	103	123	24·7	—
	,, ,,	,,	13	120	131	23·4	[2·6]
	,, fast	,,	33	114	403	21·4	—
	,, ,,	—	36	135	406	20·4	—
	,, ,,	—	40	165	401	19·2	[2·1]
	Triple.						
	Willans	Willans	39	172	400	18·5	[2·1]
CONDENSING ENGINES.	*Simple.*						
	Beam pumping, jackets	Mair	123	42	223	22·0	[2·5
	,, ,, ,,	,,	120	45	240	21·3	—
	Corliss, jackets	Longridge	488	61	520	19·3	[2·1]
	,, no jackets	,,	508	60	520	19·8	—
	Harris Corliss	Hill	166	90	606	19·4	1·9
	Reynolds Corliss	,,	163	96	603	19·5	1·9
	Wheelock	,,	158	96	596	19·3	1·9
	Sulzer, jacketed	Linde	395	75	272	19·7	—
	,, ,,	,,	284	87	372	18·4	—
	Compound.						
	Semi portable	Unwin	6	101	—	35·7	4·1
	Tandem mill	Donkin	57	53	—	20·5	1·9
	Tandem pumping, no jackets	Mair	177	70	692	20·9	—
	Receiver pumping, jackets	,,	127	61	264	14·8	—
	Worthing pump, jackets	Mair and Unwin	296	75	124	17·4	—
	,, ,, ,,	,,	255	60	121	17·7	1·78
	Tandem mill, no jackets	Longridge	888	87	442	17·8	1·78
	,, ,, ,,	,,	862	87	442	19·6	2·15
	Receiver ,, ,,	,,	314	96	478	17·0	1·96
	,, ,, jackets	,,	338	95	487	17·2	2·04
	Beam pumping ,,	Leavitt	252	99	237	13·9	—
	,, ,, ,,	,,	290	99	241	14·2	—
	Sulzer, jackets	Sulzer	267	90	690	14·0	[1·6]
	,, ,,	Uncotte	135	90	395	15·3	—
	,, ,,	Soldini	272	110	590	15·3	—
	Triple.						
	Sulzer, jackets	Sulzer	380	145	—	11·7	—
	,, ,,	Schröter	198	156	460	12·2	—
	Maschinenfabrik Augsburg) jackets	,,	700	145	[illegible]	12·45	—
MARINE ENGINES	*Compound.*						
	Fusiyama, no jackets	Kennedy	371	57	306	21·2	2·66
	Colchester ,, ,,	,,	1,979	81	522	21·7	2·90
	Triple.						
	Meteor, jackets	,,	1,994	145	574	15·0	2·01
	Tartar	,,	1,967	144	[illegible]	[illegible]	[illegible]

The large pumping engines of the Hydraulic Power Company are less favourably circumstanced for economy. They gave an indicated horse-power on trial with 2·19lb. of coal per hour. In ordinary work they are stated to use 2·93 or about 35 per cent. more. These engines have a fairly steady load during the day and a smaller load at night.

If such a case as that of an electric lighting station is considered, where the load fluctuates very greatly, the maximum load being often four times the mean load, and the minimum load one twentieth of the mean load, then the consumption per horse power is very much greater. Mr. Crompton has given the figures for the Kensington station, which has excellent Willans compound non-condensing engines. These engines will work with less than 2lb. of coal per effective horse power in trials at full load. The results obtained in ordinary workings were as follows:

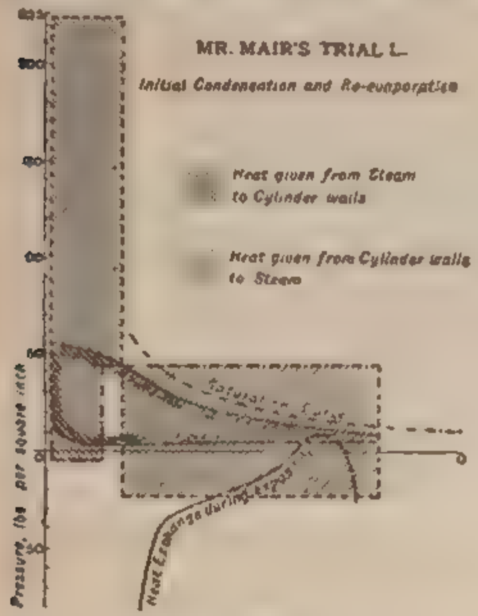


Fig. 1.

TABLE II.—Engines in Electric Central Stations.

Year.	Coal used in pounds per hour.		
	Per electrical unit generated.	Per effective h.p.	Per indicated h.p.
1886	12	8·4	6·5
1890	8	5·6	4·35
1892	7	4·9	3·8

In the discussion on Mr. Crompton's paper, instances were given of coal consumption at electrical stations still larger than any of these. Probably up to the present the consumption has in no case been less than 6lb. per unit generated; 3·8lb. per effective horse-power; or 3·3lb. per indicated horse-power. This large

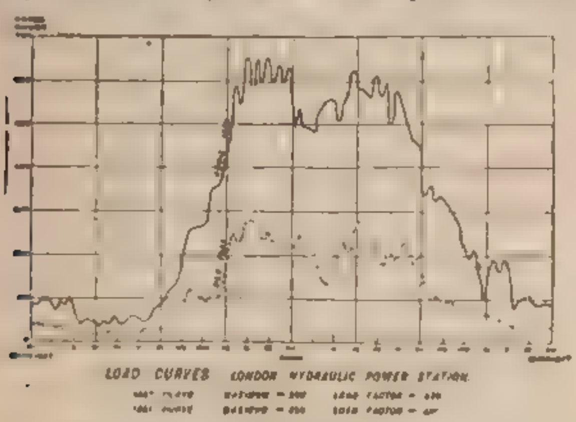


Fig. 2.

consumption will be traced later to two classes of waste—engine waste and boiler waste—due both of them to the inefficiency caused by variation of load.*

In the case of small isolated motors, not generally of very good construction or well proportioned for their work, still more extravagant results have been observed. The following Table III gives some results obtained with small workshop engines in Birmingham.

These last results are interesting only for this reason, that it is such uneconomical small engines which are displaced when central station power distribution is introduced. It is because these small engines are so extravagant that power can be distributed from a central station at profit. As to the case of electric light stations, seeing that they are central stations of the type specially considered in these lectures, it is desirable to analyse more in detail the causes of waste.

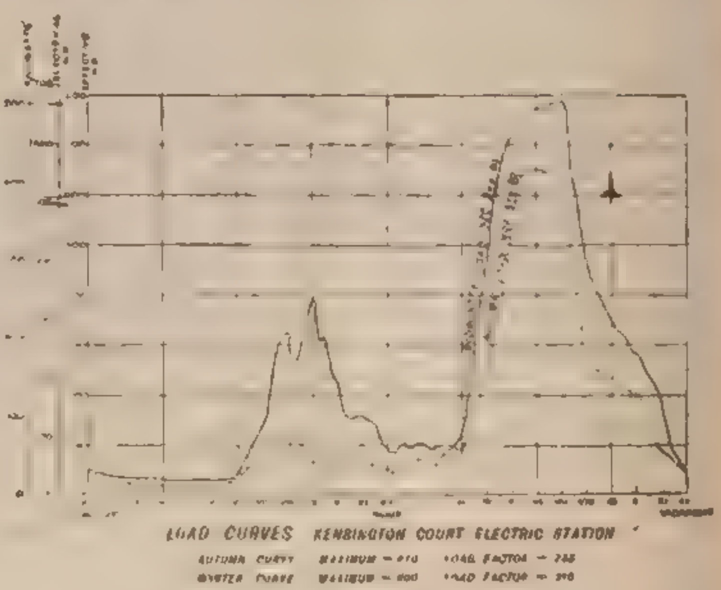


Fig. 4.

TABLE III.—Coal Consumption per Indicated Horse-power in Small Engines at Birmingham.

Nominal h.p.	Probable i.h.p. at full load.	Actual average i.h.p. during the observations.	Coal consumption in pounds per i.h.p. hour during the observations.
4	12	2·96	36
15	45	7·37	21·25
20	60	8·20	22·61
15	45	8·60	18·13
25	75	23·64	11·08
20	60	19·08	9·53
20	60	20·00	8·50

The Chief Secondary Cause of Loss or Waste in Heat Motors.—Thermodynamics shows that the efficiency of heat motors cannot

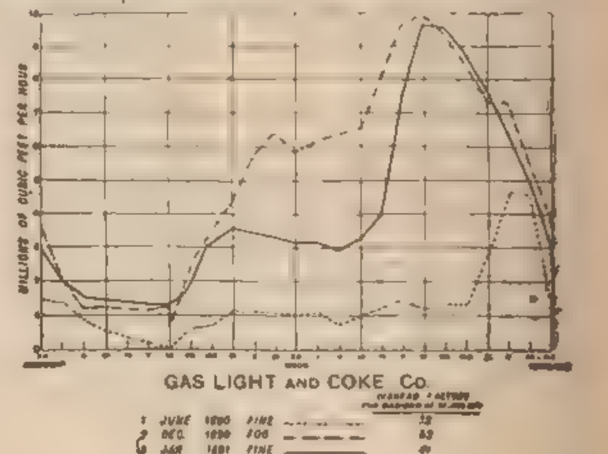


Fig. 3.

exceed a certain limit, depending on the range of temperature at which the motor works. With the range of temperature practically available a steam engine might convert three-eighths, and a gas engine one half, of the heat supply into work. No actual engine reaches even approximately this thermal efficiency. Part of the losses are due to bad construction or bad management, but a part are practically unavoidable. The principal cause of the practically unavoidable waste of heat energy is essentially the same in steam engines and gas engines; it is a consequence of the enclosure of the hot working fluid in conducting metallic walls. In steam-engines the cylinder walls condense steam during

*The latest Board of Trade returns from electric lighting stations confirm these figures. Taking the largest and best stations, the consumption of coal varies in different cases from *7lb. to 12lb. per unit* of electricity generated. It is more than *this per unit sold.*

admission, the condense steam evaporating and carrying off heat to the condenser or the atmosphere during the period of exhaust. This exhaust waste increases with the ratio of the admission surface in the cylinder to the weight of steam used per stroke. In the same engine, therefore, it increases for light loads because more surface is exposed during admission per pound of steam used. It is greater when the engine works slowly than when it works fast, the piston effort being the same. The evil can be diminished, but not entirely overcome, by steam jackets, or by superheating. It is an evil specially prejudicial when engines are used which are too large for the work to be done.

In gas engines it is necessary, to prevent destruction of the cylinder by the high temperature of the burning gases, to enclose it in a water jacket. M. Witz has shown that it is due to the cooling action of this water jacketed wall that part of the gas is kept below the temperature of combustion. The jacket therefore, diminishes the efficiency of the engine not only by directly abstracting heat, but by preventing the full development of the gas pressure early in the stroke. As in steam engines, the evil is greater the greater the wall surface exposed at the moment of explosion. This appears to be the principal reason why initial compression of the gases is necessary for good efficiency. The gases reduced by compression to a smaller volume are exposed at the moment of ignition to a smaller area of cylinder wall.

It is useful to get a clear numerical idea of the relative importance of the cylinder wall action and the other actions during a stroke, for this cylinder wall action is the principal factor in the inefficiency due to variable load or arising out of the use of underloaded engines, both matters of importance in considering the advantages of distribution of power. Prof. Dwelshauvers Dery has shown* how the heat exchange between the steam and the cylinder wall during the stroke may be represented by a diagram on the same scale as the indicator diagram. Fig. 1 shows such a diagram drawn for the data of one of Mr. Mair Rumley's engine trials. The engine was a single cylinder beam engine with jacket, working at about 4½ expansions, and furnishing 123 i.h.p. The total steam used per stroke was 1·14lb., or 31 cubic inches of water. The whole of this, if condensed and spread over the cylinder wall, would make a layer less than one hundredth of an inch thick. The range of temperature between the initial steam temperature and the exhaust temperature may be taken roughly as 200 deg., and about 30 per cent. of the steam was condensed during admission. The whole heat of this initially condensed steam would only be sufficient to heat a very thin layer of the cylinder wall from the exhaust to the admission temperature.

The dark shaded line in the figure is the indicator diagram of the engine. The saturation curve shows where the expansion line of the diagram should have been if there had been no condensation. The two shaded areas represent to the same scale as the indicator diagram the heat given to the cylinder wall during admission and compression and abstracted from it during expansion and exhaust. They represent heat quantities wasted. It will be seen easily that the cylinder wall action involves larger quantities of heat than the whole of the heat employed in doing useful work.

Load Curve and Load Factor.—A curve, the abscissæ of which represent time, and the ordinates the rate of expenditure, is called a load curve, and such curves are very commonly drawn for a period of 24 hours' working, because, apart from seasonal fluctuations, a day is a natural period in the operation of a power plant. The ordinates may be horse power or volt amperes, or units of any other quantity proportional to the rate of expenditure of energy. The area of the curve represents the total amount of energy for the period considered. A load curve may be drawn for a single engine or machine, or for a plant of many engines or machines. The load line for a central station is that to which attention is to be directed. The ordinate of such a station load curve represents the sum of the energy expended at the moment per unit of time by all the engines or machines then in operation.

Load curves for particular cases have, no doubt, been frequently drawn, and the influence of fluctuation in the rate of working on economy has been noted. But it is due to Mr. Crompton that the use of the load curve in examining the results of station working, and in discriminating the causes of differences in the results obtained in different stations, was first clearly indicated.†

It can be directly inferred from the examples given in Mr. Crompton's paper that the cost of working per unit of mechanical or electrical energy distributed in different electric lighting stations depends very intimately on the form of the load curve. Mr. Crompton introduced a term, "load factor," to express the coefficient of fluctuation of the rate of working. There may be various load factors, according to the precise fluctuation considered. But for the object at present in view, the consideration of the influence of variation of load on the efficiency of steam plant, the load factor may be taken to be the ratio of the area of a day's load curve to the area of a rectangle enclosing it. It is equally the ratio of the average load during the day to the maximum load at any time during the day. The plant must be large enough for the maximum load. The income depends on the mean amount of energy delivered. The efficiency of the engines depends on the load factor. The cost of a day's working depends partly on the average output, partly on the load factor.

Fig. 2 gives two load curves for a day's working of one of the stations of the London Hydraulic Supply Company. These indicate the kind of fluctuation of demand which occurs in a central station supplying power for a large number of intermittently working machines, chiefly lifts and hoisting machines. Such machines are in frequent use in the day and are little used at night. The demand for power water pumped by the engines at the station is large and pretty constant from 9 a.m. to 5 p.m. During the remaining hours the demand is small. The load factor for the day, understood as defined above, is 0·41 in 1887, and 0·46 in 1890, when the system had been considerably extended. This shows that as the number of consumers supplied is greater, the demand is more uniform.

Fig. 3 shows load curves for the London Gas and Coal Company. A gas generating station is essentially a central station supplying and distributing a means of producing energy either for lighting, heating, or power purposes. The ordinates in the case represent cubic feet of gas supplied per hour. If, say, 26 cubic feet of gas per hour is assumed to be capable of furnishing a horse power, it is easily seen that the ordinates of the curves to a suitable scale represent equally horse power of energy supplied. In the case of the Gas and Coke Company, the largest demand is for lighting and this is greatest in the evening. But there is also a considerable demand during the day for gas for heating and for power. The daily diagram factor was 0·41 for a day in January, falling to 0·27 for a day in June. On a foggy day in December it rose to 0·52.

Fig. 4 gives load curves for the Kensington electric lighting station. As practically the whole of the electricity generated is used for lighting purposes, the period of large demand is short, and the fluctuation of demand greater than in either of the previous cases. The daily load factor is 0·24 for one of the curves and 0·32 for the other. But for the partial use of storage batteries the load factor would have been smaller still.

(To be continued.)

* "Investigation of the Heat Expenditure in Steam engines."—*Proceedings*, Institution of Civil Engineers, vol. xcviii., 1889.

† "Electrical Energy."—*Proceedings*, Institution of Civil Engineers.

THE BRITISH ASSOCIATION.

Address to the Mechanical Science Section.

BY JEREMIAH HEAD, M.INST.C.E., PAST-PRES.INST.MECH.E., F.C.S., PRESIDENT OF THE SECTION.

(Concluded from page 261.)

Weight of Birds in Relation to their Bulk.—It is generally believed that birds are lighter, bulk for bulk, than other animals, and that to this lightness they owe, in some degree, their power of flight and of floating on water. To account for this it is said that their bone cavities are filled with air, and that some, though not even all, flying birds have small air sacs under the skin. It is clear, however, that displacement of external air by air-filled cavities can only assist aerial flotation to an infinitesimal extent, unless highly heated. Such cavities would, however, help aquatic birds to swim, if situated under the immersed portion of their bodies, which is not always the case. Some aquatic birds, such as swans, swim with head, neck, wings, tail and half their bodies out of the water. The specific gravity of fishes and land animals is clearly about the same as water. For, when swimming, they can keep only a small portion of their heads above the surface, and that by continued exertion. Are, then, birds, in the substance of their bodies less dense than other animals, although also composed of flesh, blood and bone, and these components in similar proportions and of similar character and texture? If they are, then land animals might have been made lighter in proportion to their bulk or smaller in proportion to their weight than they have been. If they are not, how is it that some of them can swim and float high out of the water? Having an opportunity recently of inspecting a large wild, or whooper swan, I ascertained its weight to be 14lb. I noticed that the whole of the under part of the body, which would be immersed when swimming, was covered with feathers and underlined with down to an average depth of not less than 1½in., or, when closely pressed, say, 1¼in. The immersed surface I estimated at 1½ square feet. The weight of water displaced by this feather and down jacket, and the consequent extra buoyancy produced thereby, was no less than 9·78lb. This would account for two-thirds of the bird's body being out of the water when swimming, even if the body were of the same specific gravity as water. I next procured a freshly shot wild duck, which weighed 2¼lb., and placed it in a tank of sea water. It floated. I found the area of its immersed surface to be 54 square inches, and the average depth of its under-feathers and down to be ⅜in. The water displaced by this envelope would weigh 1·3lb., and would support three-fifths of its entire weight. I then had it denuded of all its feathers and down, and again placed in the tank. It then slowly sank to the bottom. These experiments, so far as they go, seem to prove conclusively that birds are not lighter, bulk for bulk, than other animals, but, on the other hand, about the same specific gravity, and that their floating power lies entirely in the thick jacket or life-belt with which Nature has furnished those, and those only, which are intended to swim. Inasmuch, therefore, as the specific gravity of the actual bodies of all animals appears to be about the same, there is no reason to believe that they could have been constructed of lighter material or to lighter design.

Weight in Relation to their Energy.—But notwithstanding this uniformity of specific gravity, there remains the curious fact that flying birds can exert continuously about three times the horse power per pound of weight that man can, and, indeed, about three times what is possible for the horse. This marvellous flow of energy in proportion to weight is probably due to rapidity of heart action rather than to increase of muscular stress. I have timed

sea gulls and found them to flap their wings 200 times per minute when flying at about 24 knots per hour, and have estimated eider ducks, making about 36 knots per hour, to be flapping their wings 500 times in a minute. I say "estimated," for their movements are too rapid for precise counting. This outpouring of energy, which seems to me to be unequalled in terrestrial animals, is nevertheless maintained by birds for indefinitely long periods of time. A proportionately increased rate of combustion and renovation of tissue as well as of food consumption are necessary consequences. The higher temperature of the bodies of birds, as compared with other animals,* and the well known vivacity of those which, like sea birds, are almost continuously on the wing, are circumstances which seem to point to the same conclusion. It is confirmed by what we know of steam and other motors. For instance, if a steamship were so built and proportioned that a ton of coal per hour consumed in the boilers would maintain the pressure at 100lb. per square inch, and produce 1,000 h.p. at the propeller, and then if, without other alteration, firing was slackened until the steam fell to 50lb. per square inch, and there maintained, it is clear that the horse power produced would be greatly lessened, and so would the temperature of the steam in the boilers, steam pipes, and cylinders. Thus, other things being equal, the temperature of the steam would rise and fall with the energy given forth by the mechanism. The suggestion is that the higher temperature of birds, as compared with other animals is similarly connected with their superior power of producing and maintaining energetic effort.

Aerial Navigation.

Let us now consider what man has done, and may be able to do, in aerial navigation by aid of contrivances which, as in the case of railway locomotives and ocean steamers, are propelled by a power other than that of his own body. The scientific world is greatly indebted to Mr. Hiram S. Maxim, of London, for recording in a clear and readable form the present position of aeronautic mechanisms.† So far, the only contrivances which have been fairly successful are balloons, which, unlike birds, depend on atmospheric displacement for their power of sustaining weight or rising or falling. In balloon experiments our French neighbours have led the way from the first attempt of the Montgolfier brothers in 1783. During the last 20 years they have made numerous experiments and substantial improvements. Captain Renard and other officers of the French army have constructed a fish shaped apparatus, and inflated it with hydrogen. It is driven by an electric motor of 8½ h.p., and has sufficient buoyancy to carry two aeronauts and all necessary accessories. In fair weather Captain Renard has succeeded in travelling at the rate of 12¼ miles per hour, in steering in any direction, and even in returning to his point of departure. The balloon, it is said, always keeps level, and so far there have not been any accidents; but no expedition has been attempted in wet or windy weather. Except that a more powerful motor, going at a higher speed, might be fitted to such an apparatus, Mr. Maxim thinks that it is as near perfection as is ever likely to be reached by a machine depending on aerial flotation. He proceeds to give an account of some experiments made by Prof. S. P. Langley, of the Smithsonian Institute, Washington, and of others by himself, to ascertain how much power is required to produce artificial flight by means of aero planes, after the manner of birds, and whether such power can be obtained without exceeding the weight which it would itself sustain. He says that heavy birds, with relatively small wings, carry about 150lb. per horse power exerted, and birds such as the albatross and vulture probably about 250lb. Prof. Langley, with small slanting planes was able to carry 250lb. per horse power exerted, and Mr. Maxim using heavier weights in proportion to plane area 133lb. per horse power, and using lighter ones, nearly the same as Prof. Langley. Mr. Maxim has lately devoted his energies to constructing a motor which should meet the requirements of the case, and has succeeded, he says, in producing one, a steam engine burning naphtha and with atmospheric condenser, within a total weight of 8lb. per horse power. He thinks, however,‡ that by using light naphtha and its vapour in the boiler instead of water, as well as in the furnace as fuel, a weight as low as 5lb. per horse power may be reached. Meanwhile Prof. Langley's ideas have been embodied in an experimental flying machine, a drawing and description of which will be found in the *Daily Graphic* for July 1, 1893. The body, which resembles that of a bird, and is 15ft. long, contains the propelling machinery in duplicate. The wings, which are 40ft. across, are of China silk spread on a tubular framework, stiffened with wire trusses. The boilers use liquid fuel, and contain a highly volatile fluid. The capabilities of the machine have not yet been practically tested. Promising as are the results hitherto obtained, they are as yet far from placing us on a level with birds in power to utilise the atmosphere as a navigating medium. The absolutely necessary power of delicate guiding, in rising, falling, and turning, whatever the direction or force of the wind, has yet to be considered and worked out. What would happen in case of a temporary breakdown of the aero-plane machinery we shudder to think of. An important step has been effected by the discovery that parachutes with tubular orifices at the top are comparatively safe appliances for descending to the earth from indefinitely high altitudes. Perhaps it may be arranged that each aeronaut should be able at a moment's warning to gird himself with one of these as with a life belt on board ship, and so descend in safety, or one or more automatically opening in case of disaster might be fitted to the aero plane as a whole.

* *Chambers's Encyclopædia*, "Bird" and "Animal Heat"; "Lehrbuch der Zoologie," by Prof. Hertwig, p. 538.

† "*Progress in Aerial* Navigation," by Hiram S. Maxim, *Fortnightly Review, October, 1892.* ‡ *Engineer*, January 13, 1893, p. 28.

Eventual Exhaustion of Fuel Supply.

I have still to refer to one other question, the consideration of which must always give rise to very serious thoughts. We have seen that the decisive victories which in modern times man has gained over matter and over other animals, have been due to his use of power derived from other than animal sources. That power has invariably proceeded from the combustion and the destruction of fuel, the accumulations of which in the earth are necessarily limited. Mechanical appliances involving the consumption of fuel, have for a century at least been multiplying with alarming rapidity. Our minds have been set mainly on enlarging the uses and improving the [illegible] at all on economising the great sources of power in nature, which are now for the most part its fuels. Terrible waste of these valuable stores is daily going on in almost every department of use. Once exhausted they can never be replaced. They have been drawn upon to some extent for 1,000 years, and extensively for more than 100. Authorities say that another 1,000 years will exhaust all the more accessible supplies. But suppose they last 5,000 years, what then? Why, then, as far as we can at present see, our only motive powers will be wind and water and animals, and our only mode of transit sailing and rowing, driving, cycling, riding, and walking. Sir Robert Ball has estimated that in not less than 5,000,000 and not more than 10,000,000 years the sun will have become too cold to support life of any kind on this planet. Between the 5,000 years when fuel will certainly be exhausted and the 5,000,000 years when all life may be extinguished there will still be 4,995,000 years when, according to present appearances, man will have to give up his hardly earned victories over matter and other animals, and the latter will again surpass him, each in his own element, because he has no fuel.

Conclusion.

Leaving to our posterity these more remote troubles, we may, I think, justly draw from the entire discussion the conclusion that we have still a great deal to learn from mechanisms as they exist in nature. Great as have been the achievements of man since he first began to study mechanical science, with a view to directing the great sources of power in nature for his own use and convenience, the entire field of research is by no means yet fully exhausted. We must continue to study the same science with undiminished ardour. In so doing we shall do well to bear in mind that success can be achieved only by the patient, accurate, and conscientious observation of the great facts of nature, which are equally open to us all and waiting for our attention; and by drawing correct inferences therefrom, and by applying such inferences correctly to the fulfilment of the future needs and destiny of our race.

ELECTRIC LIGHTING IN CHELSEA.

By the courtesy of Mr. T. W. E. Higgens, surveyor to the Chelsea Vestry, we are enabled to place before our readers the following information, which is taken from Mr. Higgens's report to the Vestry for the year ending 25th March last:

Electric Lighting. The number of houses lighted by electricity in Chelsea was

	1890-1	1891-2	1892-3
Chelsea Electricity Supply Company	215	312	390
Cadogan Electric Light Company	16	18	–
London Electric Supply Corporation	2	2	—
	233	332	390

At the beginning of the year the Cadogan Electric Light Company was supplying electricity without an order. The St. Luke's Chelsea Electric Lighting Company had obtained an order, but had not satisfied the Board of Trade as to their financial position. The time for satisfying the Board of Trade having expired, the Vestry agreed to an extension of time, so as to enable the St. Luke's, Chelsea, Company (which appeared to be the Cadogan Company under another name) to satisfy the Board of Trade. They did not, however, do so, and as complaints were received of failure to supply light, the Board of Trade, after receiving a representation from the Vestry, cancelled the order, and the Chelsea Electricity Supply Company are now supplying the houses formerly supplied by the Cadogan Company.

As regards the cancelling of this order, I consider the action taken by the Board of Trade to be most satisfactory. It has always seemed to me to be a mistake to have allowed a private company, acting without statutory authority, to break up the public streets and supply electricity without proper supervision. It is true that the Cadogan Company entered into an agreement with the Vestry, and in virtue of that agreement they opened the streets; but that agreement did not enable the Vestry to control the company in their supply of electricity, and as a result of this absence of control great inconvenience was caused to most of the persons who obtained their current from this company.

When companies obtain statutory powers to open streets and supply electricity they are very justly, compelled to fulfil certain obligations in return for their privileges; but under their agreement with the Vestry (which was an illegal one) the Cadogan Company obtained privileges without corresponding obligations being enforced. This company, during some period of their existence, were supplying electricity at high pressure. The Board of Trade enforce certain restrictions and regulations upon any company which obtains an order or Act of Parliament before supplying

electricity, and their regulations as regards a high-pressure supply are of great value for the public safety, but as the Cadogan Company had no license order, or Act, no restrictions or regulations were enforced or could be enforced by the Board of Trade except as regards their overhead wires, and the Vestry had no means of knowing whether the supply of electricity by that company was at a constant voltage, whether it varied, or whether any attempt to regulate the supply was made.

Pressure Records. From time to time I have examined the records of pressure kept by the Chelsea Electricity Company. During the earlier portion of this year the pressure appeared to be very constant, but during the summer the recording ... the wire broke, and for some little time the record could not be kept with the usual accuracy; when, however, the wire was repaired, the pressure did not appear quite so regular, but towards the end of the autumn the pressure once more regained its regularity. The pressure record kept by this company is most satisfactory, arrangements are made to supply the consumers at as near 100 volts as possible, and there is seldom any appreciable variation of pressure.

Overhead Wires. -In June, 1892, I represented the Vestry at the Board of Trade enquiry as to the suggested by-laws for regulating overhead wires, and in October the by-laws were issued. Under these by-laws the persons owning wires are compelled to deliver to the local authority full particulars of all wires fixed by them within six months of the approval of the by-laws.

BUSINESS NOTES.

Great Horton.—An electric light installation is being put up at the Beckside Mills of Messrs. Joseph Benn and Sons, Great Horton.

Blackpool.—The central station is now in working order, and extensive use is made of electricity as an illuminant at the Winter Gardens.

Globe Telegraph and Trust Company.—An interim dividend of 3s. per share is announced on the preference and 1s. 6d. on the ordinary shares.

Swinton and Pendlebury.—The Local Board have referred to a committee of the whole Board the question of applying for a provisional order.

West India and Panama Telegraph Company.—The receipts for the two weeks ended September 15 were £323 less than for the corresponding period.

Brighton.—The Town Council have decided to light the Masonic Rooms at the Pavilion with electricity, provided that the Freemasons pay an increase of rent of £20 a year.

Croydon.—The Rural Sanitary Authority have granted permission to the National Telephone Company to erect poles on the sewage farm at Merton to support telephone wires.

Eastern Extension, Australasia, and China Telegraph Company.—The Directors have declared an interim dividend for the quarter ended June 30 last of 2s. 6d. per share, free of income tax.

Blackburn.—The Corporation, as will be seen from our advertisement columns, invite tenders for the supply and erection of boilers, dynamos, cranes, cables, conduits, accumulators, switchboards, etc.

Mumbles.—The Mumbles Local Board are considering the advisability of introducing electric lighting in the village, and Mr. J. Stansfield Brun, C.E., surveyor, has been instructed to draw up a report on the subject.

Joined in Parallel.—We are informed that on the 13th inst. the marriage took place, at Grafton-square Church, Clapham, of Mr. W. J. Fryer, A.I.E.E. (Messrs. Graham and Baddle, Oxford street), and Miss Maggie Nyren.

Western and Brazilian Telegraph Company.—The traffic receipts for the week ended September 15, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £1,220.

Warminster.—The chairman of the Local Board, in reply to a question at a meeting last week, said that he hoped to be in a position to report something definite with regard to the introduction of the electric light by the next meeting.

City and South London Railway Company.—The receipts for the week ending September 17 were £756, against £744 for the same period last year, or an increase of £12. The total receipts for the second half year of 1893 show an increase of £440 over those for the corresponding period of 1892.

Harrogate.—A letter was read at a meeting of the Town Council last week from Mr. Priestly, of Halifax, with regard to a refuse destructor to be used in the raising of steam in connection with the electric lighting installation. The letter was referred to the General Purposes Committee.

Telegraphic Communication Restored.—The Western and Brazilian Telegraph Company, Limited, announce that the Brazilian Government have withdrawn their restriction as to the sending of telegrams, but messages must be in plain language and in no way refer to the state of affairs in Brazil.

Personal.—We understand that Mr. C. A. Hemingway, who for the last seven years has been in the employ of Messrs. Drake and Gorham, electrical engineers, 66, Victoria-street, Westminster, has now severed his connection with the above firm, and has commenced business as electrical engineer at 10, Petersham-road, Richmond, Surrey.

Maidstone.—At a meeting of the Local Board last week Mr. Barker asked what had become of the electric lighting question. The Town Clerk replied that a meeting of the committee would be held very shortly; it had stood over owing to the absence of various members. The question had been referred to a committee of the whole Board.

Hope-Jones Electric Organ Company.—A concert was given last week at Birkenhead by Mr. Robert Hope-Jones to the workmen of the Company and friends. In an interval Mr. Hope-Jones mentioned that 12 months ago 16 men did the work of the firm, that now there were 100 men engaged, and that there was work sufficient for twice that number.

Universal Lathe.—Messrs. Lotz, Abbott, and Co., of 144, High Holborn, W.C., inform us that they have been appointed the sole selling agents for Great Britain, the Colonies, and also for the United States of America, for the sale of the Pittler's universal lathe. Various styles and sizes of these machines in practical operation may be seen at the above address.

Wolverhampton.—Alderman W. H. Jones formally introduced the electrical engineer to the Council at a meeting of the latter last week. The committee, he observed, were anxious to perfect their scheme and as soon as possible bring the matter before the Council. The delay had been owing to the fact that the engineer could not get to Wolverhampton until the termination of his three months' notice.

Cork.—The Corporation have referred to the Law and Finance Committee a letter from Mr. Robert Starke, convener of the Telephone Committee of the Glasgow Corporation, relating to the telephonic system, and requesting the attention of the Council thereto, in view of its pressing importance to corporations. The primary object was to get the telephone system into the hands of corporations, and not private companies.

Gillingham (Kent).—When the members of the Local Board met last week, several of them complained of the bad light from the gas lamps in the street. Mr. Beveridge said it would be a good thing when they got the electric light at Gillingham and had a little opposition. It seemed to be no use complaining to the gas company. The Chairman said that they could not help it, and that he wished they had the electric light.

St. Pancras.—The Vestry have sanctioned extensions of the electric lighting station by the addition of three 90-unit engines and dynamos and three boilers at the existing Regent's Park station, with another sub-station in Regent's Park road. These extensions will enable to be served a further 5,000 16-c.p. lamps installed. It has also been decided to construct a second station, in combination with a refuse destructor, in King's road.

Govan.—At a meeting of the Govan District Lunacy Board, Mr. Findlay, in moving the adoption of the Building Committee's minutes, referred to the report by an expert on lighting the Hawkhead Asylum with electricity, which stated that the installation would cost £5,300, and that the yearly upkeep would amount to £269. Mr. Findlay suggested that the whole matter should be referred back to the committee, which was agreed to.

Derby.—The House Committee of the Board of Guardians recommended, at a meeting of the latter on Tuesday, that an expert should be employed to report to what use a steam engine now standing idle at the workhouse could be put, his fee not to exceed five guineas. The Rev. H. R. Roll said it was thought the engine might be utilised for the purpose of supplying the workhouse with electric light. The matter was referred back to the committee.

Newtown.—The Newtown and Llanllwchairn Local Board met last week, and it was mentioned that the Street Lighting Committee had decided to adjourn the question of lighting the town by electricity for six months. The Chairman said that they had had a long report from Messrs. Tozer and Rooper as to supplying the town with electric light, which would cost a little less than gas, and the town would reap many advantages if they adopted electric lighting.

New Issue.—The National Electric Supply Company, Limited, invite applications for a portion of an issue of £20,000 of debentures, bearing interest at the rate of 4½ per cent., payable on September 1 and March 1, for which coupons payable to bearer are attached. The debentures are repayable at par on September 1, 1900. These debentures are a first charge upon the entire property and undertaking of the company, secured by deed to trustees for the benefit of the debenture holders.

Dorchester.—The Town Clerk mentioned at a meeting of the Council on the 15th inst. that he had received Messrs. Newton's report upon the electric lighting of the town, but he thought it had better go to committee. This course was agreed to and the Council there and then resolved themselves into committee to receive the report. Eventually however, it was decided not to hear the report read then, but to have it printed and a copy sent to each member of the Council for perusal.

Haddon Hall.—We understand that Messrs. Drake and Gorham were entrusted with the lighting arrangements in connection with the recent Primrose League demonstration of the Bakewell and other local habitations at Haddon Hall, the historic seat of the Duke of Rutland, and that the effect produced by four Crompton-Pochin arc lamps was extremely good. Very short notice was given for the carrying out of the work, but notwithstanding this everything passed off highly satisfactorily.

Leeds.—The Parliamentary Committee of the Leeds Corporation considered on the 15th inst. the proposal of the Government to take over the trunk lines of the National Telephone Company. Communications on the subject were read from Glasgow, and also

from the Manchester Guardian Society for the Protection of Trade. It was resolved to write to the members for the city, along with the member for the Pudsey division, asking them to keep a watch on the pending negotiations in the interests of the districts.

Lighting at Lambeth.—A letter was read from Mr. W. H. Preece at a meeting of the Board of Guardians on the 13th inst., stating that two boilers would be required for the electric lighting scheme for the workhouse and infirmary, and the details of which were given in our issue of the 8th inst. He estimated their cost at £800. Mr. Pialcox withdrew his motion with reference to supplying Mr. Stacey Gold with a copy of the minutes and agenda in order that he might obtain further information regarding the practice of other unions. The Board agreed to postpone its consideration.

Lighting at Pontypool.—The use of the electric light is extending in this town. The shops of Messrs. W. Pegler and Son and Mr. J. Daniel are effectively lighted by electricity, while Mr. Hall, of The Ship, lights a considerable part of Crane street by a powerful lamp placed over the entrance to his hotel. The illuminant seems in a fair way of coming into general use, both for shops and private houses. The improvement in the lighting of the drapers' shops is very marked, and Messrs. E. Fowler, R. W. Wooley, and E. Jones have all been most liberal in the use of a large number of 200 c.p. lamps.

Yarmouth.—The Town Clerk mentioned at a meeting of the Council last week, that the Local Government Board, prior to sanctioning the loan asked for by the Council for the purpose of electric lighting, required that the site upon which it was proposed to erect the buildings should be vested in the urban authority. The Finance Committee recommended the Council to grant to the urban authority, for the purpose of an electric light station, a piece of land on the east side of the Southgate road, measuring 140ft. from north to south and 100ft. from east to west. The recommendation was adopted.

Leamington.—At a meeting of the Town Council last week Alderman Gilbert enquired why the sub-committee had not met to consider the question of telephonic communication. Mr. Passman replied that the committee had not been called together because everyone had been taking his holidays. He then read letters he had received from Mr. Bezant and the manager of the telephone company as to connecting the corporate offices, etc., with the exchange. Alderman Gilbert moved that the letters be referred to the telephonic sub-committee. The sub-committee was to meet on the 14th inst. to consider the matter.

Newcastle-on-Tyne.—The Tyne Improvement Commissioners have agreed to light the Commissioners' offices by electricity, and Messrs. Temple, Stout, and Green have been appointed a sub-committee to carry out the arrangements. Messrs. C. A. Parsons and Co. have issued a pamphlet dealing with installations carried out by them. It is illustrated by means of Meisenbach blocks, and has fine plates of the exterior of the Central railway station, Newcastle, showing the electric lamps there; a view of the works of the Newcastle and District Lighting Company, Forth Banks, and the electric lighting station at Cambridge.

Camborne.—An electric light installation has been put up at the works of Messrs. Holman Bros., the well-known ironfounders and rock drill specialists, at Camborne. This firm is the first in the town to take the initiative in laying down an installation for illuminating purposes, and it is, with the exception of Dolcoath Mine, the first in the neighbourhood. The installation consists of 46 Edison-Swan incandescent lamps, and several Crompton arc lamps ranging from 2,000 c.p. to 500 c.p. A Crompton dynamo is used, driven by a two-cylinder engine made by Holman Bros. The installation has been carried out by Messrs. Veale and Co., Limited, of St. Austell.

Cambridge.—The Guildhall and Building Committee of the Town Council reported at a meeting of the latter on the 14th inst. that they had invited estimates from two local firms for the installation of the electric light in that portion of the Guildhall comprising the small assembly room, the alderman's parlour, and the exit to Peas hill. Tenders had been received from both firms, and the committee recommended the Council to accept that of Messrs. Medhurst (now Messrs. Russell and Co.), at £37. 5s., subject to a slight alteration in the lamps to be used in the small room and alderman's parlour, which would entail an additional cost not exceeding £5. Councillor Bell moved and Alderman Whitmore seconded, the adoption of the report, which was carried.

Edinburgh.—At a meeting of the Town Council last week, Bailie Macpherson moved the acceptance of estimates for work in connection with the new public baths to be erected at Caledonian crescent, Dalry. He said an idea had suggested itself in view of the fact that there was found to be a surplus of steam at the Powderhall destructor. As the Council was aware, the intention was to have a destructor also in the Dalry district, and he now proposed that when they were erecting the new baths at Caledonian crescent they ought to give instructions for wires to be put through the establishment, so that when the destructor was built they might utilise the surplus steam from it in the lighting of the baths by electricity. No extra cost would be involved. The estimates were accepted.

Dundee.—At the monthly meeting, on the 14th inst., of the Police Commission, reference was made by Mr. Brownlee to a minute of a sub-committee of the Lighting Committee recommending the erection of 36 electric lamps in the central streets of the city, provided that the Gas Commissioners would supply the light to the lamps at £20 each. Mr. Brownlee pointed out that by adopting the minute the Commission committed itself to an expenditure involving a very large capital outlay. The addition of the lamps meant an expenditure of between £6,000 and £7,000. The Clerk explained that the whole work was to be done at once, but the cost was to be spread over three years. Mr. Ritchie said that unless they were prepared to face the expenditure for a permanency there was no use of going on. The minute was approved.

Huddersfield.—The electric lighting scheme of the Corporation originally provided for the supply of electrical energy for the purpose of illumination to the central business part of the town. In consequence of the demands for supplies to residences in the Edgerton district, mains by which the energy will be conveyed are being laid. When completed, the extension will cover a lineal measurement of about two miles, a considerable number of the large residential establishments receiving installations. The Town Hall has been equipped with the electric light, and it is estimated that the total cost of this improvement and the redecoration will be about £1,500. Messrs. Mather and Platt, of Victoria street, Westminster, have put in the electrical fittings under the direction of Mr. A. B. Mountain, the borough electrical engineer. The number of lamps fixed is about 750, equivalent to 2,200 lights of 8 c.p. The current is obtained from a special transformer station in the basement of the Corporation offices.

New Electric Pumping Plant.—A set of new electric pumping plant has been constructed for the Shilbottle Colliery by Messrs. Ernest Scott and Mountain, Limited, of Newcastle, and on Saturday the plant was tested at the company's works. The plant is capable of delivering 200 gallons of water per minute against a head of 185ft. The dynamo is of the improved "Tyne" type, shunt wound, and constructed to give an output of 50 amperes at an E.M.F. of 500 volts when running at a speed of approximately 700 revolutions per minute. It is fitted with gunmetal protection guards over the armature, in order to prevent any dust or dirt getting to the armature whilst running. The conducting cables consist of 1,232 yards of concentric cable. The pumps are of the three-throw type, capable of delivering 200 gallons of water per minute against a head of 185ft., and are driven by a 25 h.p. Tyne electric motor. The power from the motor is transmitted to the pumps by means of a belt driving on to a countershaft which is geared into the crankshaft. A large number of engineers witnessed the test, which was satisfactory.

Salford.—On Tuesday Mr. S. J. Smith, C.E., Local Government Board inspector, held an enquiry relating to an application by the Salford Corporation for authority to borrow £50,000 for the purpose of electric lighting. The Town Clerk explained that the Corporation were empowered by the Salford Electric Lighting Order, 1890, and the Confirming Act to supply an electric engine within the borough, and to secure land and do other matters incidental upon such supply. The Corporation had accordingly secured a piece of land fronting Walness road for £2,774. It was not proposed to proceed with the entire scheme at once, but it was intended to expend only £32,000 of the £50,000 applied for in the initial operations. The scheme affected the entire borough, and it was anticipated that it could be carried into effect within six months of the date on which sanction was given. A period of 20 years would be requested for the repayment of the loans. Mr. Edward Manville, M.I.C.E., electrical engineer to the Corporation, gave evidence as to the details of the alternating-current system, which it is proposed to adopt.

Paignton.—Two letters from electrical engineers, offering to light the town by electricity, were read at a meeting of the Local Board on Monday. A London firm wrote: "Hearing that your good townspeople are contemplating lighting your rapidly increasing and attractive town with electric light, I shall esteem it a favour if you would kindly give me any particulars in respect of same, also whether the Corporation would be inclined to entertain a scheme for running electric launches or ferry boats to and from Torquay during the summer." Messrs. Samuel Williams and Co., Cardiff, enquired if the Board was in a position to go into the question of electric lighting; if so, in return for the concession, they were prepared to provide and work the necessary plant. Mr. Bridgman pointed out that Paignton was behind little American villages in this matter. Surely Paignton ought not to remain behind the times. He moved that a committee be appointed to enquire into the subject and report. There was no reason why, if people dangled these offers before them, they should not have a nibble. Mr. Parnell pointed out that an electric light committee already existed. The letters were referred to the committee.

Lighting at Taunton.—The Watch, Lighting, and General Purposes Committee of the Town Council at a meeting on the 12th inst., stated that they had ordered the electrical engineer to be instructed to report to every meeting of the committee. The committee had instructed the surveyor to erect a new office at the electric lighting works, using old materials as much as possible. The committee recommended that the following assistants be appointed: Messrs. Couzens, Phillips, and Thornhill, at the respective salaries of £70, £60, and £40, subject to one month's notice on either side, and Witham without salary for six months. They also recommended that the pupils be articled to the Council, that the engineer be paid quarterly his proportion of the premiums, and that Mr. Alfred Ernest Witham be retained at his present salary of £30 a year to collect meter rents and other income connected with the electric lighting, and to keep the books connected with the business department thereof. The committee had arranged for Dr. Fleming to visit Taunton during the present month. The committee recommended that underground wires should be laid along Billet street to Salisbury House. Councillor Potter moved the adoption of the report, and Alderman Van Trump seconded. Councillor Westlake proposed that the question of laying underground wires along Billet-street should be

referred back to the committee, and Councillor Vile seconded. He remarked that it would be a bad principle to undertake the work unless they knew what income would be derived from it. After further discussion, the amendment was put and carried by ten to seven. The rest of the report was adopted.

The Ealing Tenders.—The following list shows the tenders sent in for wiring the public buildings:

Binko and Co.	£684
Brown and Co.	700
Spagnoletti and Co.	793
Paterson and Cooper (accepted)	795
Taylor, Smith, and Co.	842
Emanuell and Sons	853
Lund Bros.	871
Howard and Co.	875
R. A. Scott	903
Brush Company	920
Phipps and Co.	990
Rawlings Bros.	1,020
Johnson and Phillips	1,099
British Electric Company	1,119
Nicholson and Tyler	1,125
Thomas Digby	1,130
Sax and Co.	1,149
Baily and Grundy	1,188
MacClellan and Co.	1,249
R. Dawson	1,252
Crompton and Co.	1,259
Strode and Co.	1,277
S. Cutler and Sons	1,362
B. Verity and Sons	1,376
W. Mackie	1,611
Tickner	2,187

Rockhampton Gas and Coke Company, Limited.—The report of the Directors for the half year ended June 30, 1893, states that, taking everything into consideration, the Directors have reason to congratulate the shareholders upon the satisfactory results of the past half year. The gas operations show a profit of £1,940. 14s. 9d. The electric light operations show an actual loss of £115. 15s. 5d., to which is added £289. 13s. 7d. interest upon the capital involved in the electric light plant and buildings, etc., making a debit balance in all of £414. 9s. The net profit for the whole of the Company's business is, therefore, £1,526. 5s. 9d. A great improvement appears in the electric light revenue as compared with that of the preceding half year, while the working expenses are much reduced. The number of customers for the light is increasing, and public lighting with high power arc lamps will be inaugurated on the Fitzroy Bridge in the course of a few months. In view of the large sum vested in the gas interests, the Directors have thought it inadvisable to push the electric lighting operations, but have preferred to allow this portion of the Company's business to expand on its own merits and in response only to unsolicited applications for the light. The Directors anticipate being able to report an actual profit upon the electrical business at the next meeting of shareholders. The gas consumption for the half year is slightly below that of the corresponding period of last year, but every attention is being directed to the extension of this section of the Company's business, and particularly in those outside and scattered districts where the gas-mains are already laid but, comparatively speaking, little used. Special concessions will be made in such districts to induce the residents to become consumers of gas. The Directors recommend the payment of a dividend at the rate of 10 per cent. per annum, amounting to £1,721. 18s. 2d., which will necessitate the appropriation of £200 of the reserve fund for equalisation of dividends.

Lighting at Wakefield.—The members of the Town Council last week discussed the question as to whether or not an application should be made to the Board of Trade for a provisional order under the Electric Lighting Act, authorising the Corporation to supply electricity. The Mayor (Councillor J. S. Booth) presided. Councillor W. Moorhouse, in proposing that a provisional order be applied for, said that as the public lighting of the city was at present under the control of the Sanitary Committee it was perhaps desirable that he should make one or two observations in moving that resolution. In January of the present year a special sub committee was appointed to consider the advisability of adopting the electric light in the city, and, acting on instructions given at a meeting in February, many enquiries were made from other corporations who had carried out electricity works, and others who contemplated doing so, with the result that in May the Council, by a unanimous vote, empowered the town clerk to take the necessary legal steps for securing a provisional order. In preparing that provisional order it was found that the services of an electrician were required, and as the time had arrived when it was necessary that a full and special report should be prepared by a specialist to guide the committee in deciding upon the best system to adopt, it was thought best to at once appoint a consulting electrical engineer. Mr. Hammond, of London, who was appointed at the Council meeting on Tuesday night, had had an interview with a committee of the whole Council, and the members were favourably impressed with the knowledge he possessed of the subject. As he (Mr. Moorhouse) had stated before in that Council chamber, he firmly believed the electric light would be the light of the future, and they would fail in their duty if they did not introduce it to the citizens of Wakefield at the present time. There could be no doubt that every year the Legislature was imposing new duties upon local authorities, with the result that local taxation was beginning to weigh rather heavily, and in his opinion if they were to continue in the path of progress it could only be done in face of the present monopolies by securing the electric light. He thoroughly believed there would be a demand for it, and that it would eventually be a source of revenue to the Corporation. It was evident the Council had now arrived at that period when they must decide the question either one way or the other. There was a demand for electricity in the town, as a private company had already applied for the right to supply. The County Council, he understood, had decided to light their new offices with it. If the Council pushed on their works with energy, perhaps they might be able to supply it if the resolution was carried. There was no doubt that in the past corporations who had had the control of the water and gas supplies had made profits which gave enormous relief to the rates, and those corporations who did not possess them might well look on with envy. Wakefield had now another chance, and he did hope for the sake of the town the Corporation would not let that opportunity pass by. It was well known that the gaslight had been a very successful undertaking financially in Wakefield, and the success of the gas industry was in his judgment, but an imitation of the success of the electric light in the future. There could be no two opinions about the merits of the two lights, and provided electricity could be supplied at the same rate as gas, which most assuredly it would be in the future, he ventured to assert that 90 out of every 100 persons would prefer the electric light, not only because of its brilliancy, but because it was less detrimental to health and did not do the damage to decorations and stock in trade that gas did. There could be no doubt that from the mere fact that the electric light did not produce heat, it was much better on that ground alone for lighting up public buildings, churches and private workshops, and offices of any sort. If the Council should pass his resolution that night, the provisional order would be applied for during the next month (October) and then it would come into force in June or July of next year, from which period two years would be allowed by the Board of Trade in which to erect the works. Councillor Smith seconded the resolution, and, after the matter had been fully discussed, the resolution was put to the meeting and was adopted.

The Tramway Question at Halifax.—In our last issue we briefly referred to the decision of the Town Council regarding the proposed introduction of electric tramways in that town, and as the matter is of considerable importance, we have no hesitation in amplifying as follows the paragraph given last week. It appears that a controversy had arisen on this matter through a recommendation to the Council by the Board of Works Committee to accept the terms of a company for the introduction of electric tramways. The Mayor (Alderman James Booth), who presided at the meeting, suggested that the first matter the members should consider was whether it was desirable to have tramways in the town. If they decided in the affirmative, then they might debate the other questions arising out of the subject. Councillor W. H. Spencer said that although perhaps many members were in favour of tramways being laid in Halifax, they were opposed to them at the present, not having a desire to unduly load the rates. Speaking for himself, he was opposed to the scheme that had been mentioned. Councillor H. E. Greenwood moved a resolution to the effect that the time had not arrived when it was desirable to have tramways constructed in the borough. He said no request had been made for them by any of the burgesses, and such a demand ought to be made, because they would have to pay the cost in the first instance. In the second place, there were no streets in the town where any kind of tramways could be laid down with advantage. Then there had just been introduced a system of penny 'buses, which the public appreciated. He thought the system, which was highly satisfactory, answered all the needs of the present. He should like to see these tried further before the Council took any step either towards expenditure on tramways or to the granting of a lease to a private company, but he should be opposed to the granting of a lease to any private company. Councillor Maude seconded the proposition. He favoured the idea that it would be best for the Corporation to take the tramway question in hand whenever brought forward. Probably in two or three years the Corporation would be in a much better position to consider it. The Town Clerk suggested, in place of the resolution, the words: "That the question of introducing tramways into Halifax be adjourned *sine die*." This suggestion was adopted. The Town Clerk, in reply to Councillor Maude, said it should be distinctly understood that, even if the Corporation decided itself to introduce tramways, they could not legally work them without a special Act of Parliament. In answer to Councillor Wade, the Town Clerk replied that the Leeds Corporation had obtained these special powers to take over the tramways in their city. Councillor Davenport asked if the same course had been adopted in Huddersfield. The Town Clerk answered that he did not know what other towns had done, but without the consent of a Corporation no company could introduce tramways into any town. Assuming that the Corporation allowed a company to come into Halifax, the Act gave them power, after the expiration of 21 years, to purchase the tramways at a valuation if they gave six months' notice; if they neglected to give the necessary notice, then they would have to wait seven years more before they could give a similar notice, and so on. Councillor Spencer was very glad the subject was to be left in the mystery that shrouded it. They felt relieved from the fact that the vice chairman of the Board of Works Committee, who was one of the sub commitee from whom the resolution came, now opposed the introduction of the tramways. He (the speaker) only wanted to dissent to one remark with regard to the financial aspect of the question. They could raise the whole of the money easily if they desired to do so. He thought the resolution should express the

desirability of having municipal tramway lines, to be laid from time to time as the requirements developed, and to be leased to companies in accordance with the terms mentioned by the town clerk. But as regarded the overhead trolley system, he was utterly opposed to it on several grounds. In the first place it was a disfigurement to a town, and then he considered the system was certain financial failure to whoever undertook it, owing to the quarrels it led to with other electrical concerns, such as telephones and telegraphs. He wished the resolution that expressed the opinion of the Council that it was desirable to lay municipal tramways to be leased, but that at the present time it was inexpedient for the borough to enter upon an undertaking, though not upon the ground of their being unable to raise the money. Alderman Tattersall moved as an amendment "That in the opinion of the Council the construction of an efficient tramway system is desirable as soon as the finances of the borough will admit of it being done, and that such tramways when constructed should be under the control of the Corporation." Geographically the town was badly situated for the adoption of a tramway system, and the streets were altogether unfavourable. In any case he was opposed to the Corporation, after allowing a private company to step in, waiting till its term expired before the system could be bought by the town, and that probably at enormous cost. But he did not think a move in this direction at all necessary at present. A few years would alter things. A number of county borough councils were taking over existing tramways hitherto worked by private companies, and they had an illustration of the great cost of the process in what the Leeds people were having to pay. When it was possible to have a tramway system in Halifax, then the most sensible policy would be for the Council to construct the same, obtaining powers to work it by Act of Parliament. Tramways were ostensibly for the convenience of the public. If the concern paid, the public would then reap the benefits; if not, then they ought to bear the loss. Councillor Lister seconded the amendment, for the reason that he considered if a tramway system were introduced into Halifax, it should be not only owned but also controlled and worked by the Corporation. He was also of opinion that the present time was not a time when the Corporation ought to embark upon a large enterprise of this kind. The Bradford Corporation had been considering the question very carefully of laying down and working an electric tramway on the Wakefield road, and in view of that they had made an experiment not long ago on the tramway between Foster square and the Grammar School. He had some conversation with the deputy town clerk, who informed him that the cost was very excessive indeed, and that if the overhead trolley system were adopted, the annual loss to the borough was estimated by the borough engineer at about £845, while if the conduit system were adopted, the loss would be about £1,100 per year. It would be wise to defer the consideration of the question, because in the course of a few years they might see electrical science in its application to tramways brought to a more perfect state than it was at present, and made to work in a more economical manner. Councillor Maude said he did not see the importance of Alderman Tattersall's amendment, because it bound the future Town Council, who might decide otherwise than according to this amendment. The proposition left it an open matter with a future Council. Councillor Butler supported the motion. They had had before them, and would have again shortly, the question of electric lighting, and it was a fact, he believed, that when tramways and electric lighting were adopted in one borough, the two systems were materially benefited. Councillor Woodhead supported the motion. He could have accepted Alderman Tattersall's amendment but for the fact that it pledged to some extent a future Council, and that he thought was undesirable. Further, there was scarcely a through street in which tramways could run. One or two corners, notably the White Hart and George-street, wanted widening before a tramway scheme was adopted. It was also desirable to see the development of the electric lighting scheme before any action in this direction was taken. Eventually the amendment was rejected, and the resolution was adopted, as mentioned last week.

PROVISIONAL PATENTS, 1893.

SEPTEMBER 11.

17025. **Improvements in raising and lowering the light of electric glow lamps.** Thomas Bedworth Sharp, County chambers, Martineau street, Birmingham.

17030. **Improvements in apparatus for facilitating the erection or fastening of electrical conductors in wood casings.** Gerald St. John Day and William Henry Wheeler, 64, Barton arcade, Manchester.

17045. **Improvements in or relating to electric clocks, part of such invention being also applicable for other purposes.** John Henry Gash and Joe Skinbeck, 323, High Holborn, London.

17052. **Improvements in arc electric lamps.** William James Davy, 161, Huddleston road, Tufnell park, London.

SEPTEMBER 12.

17093. **Improvements in or relating to electric telephones.** Thomas Sloper, 14, Brittox, Devizes.

17127. **Improvements in electrolytic cells.** Thomas Craney, 45, Southampton buildings, Chancery-lane, London. *(Complete specification.)*

17175. ***Improvements in or relating to electric telephones and microphones.*** *Thomas Sloper, 11, Brittox, Devizes.*

SEPTEMBER 13.

17172. **Improvements in air and water tight covers for junction-boxes used in electrical distribution and for other purposes.** Sydney William Baynes, 37, Spring gardens, Manningham, Bradford.

17189. **Improvements in electric switches.** John Macintosh Mackay Munro and James McFarlane, 151, St. Vincent-street, Glasgow.

17197. **Improvements in dynamo-electric machinery.** Rookes Evelyn Bell Crompton and Sydney Linton Brunton, 55, Chancery lane, London.

17220. **Improved methods of recovering zinc from the waste products of galvanic batteries.** Carl Anton Johannes Hugo Schroeder and Heinrich Eugen Richard Schroeder, Whetstone House, Heslop road, Balham, London. (Complete specification.)

17221. **New or improved galvanic batteries.** Carl Anton Johannes Hugo Schroeder and Heinrich Eugen Richard Schroeder, Whetstone House, Heslop-road, Balham, London. (Complete specification.)

17234. **Improvements in electric switches for series circuits.** Albert Augustus Goldston, 4, South street, Finsbury, London.

SEPTEMBER 14.

17310. **Improvements in contact apparatus for receiving currents from overhead conductors on electric railways.** Siemens Bros. and Co. Limited, 28, Southampton-buildings, Chancery lane, London. (Messrs. Siemens and Halske, Germany.)

17330. **Improvements in holders for incandescent electric lamps.** John Wigham Edmundson and Frederick James Satchwell, 46, Lincoln's-inn fields, London.

SEPTEMBER 15.

17341. **Improvements in alternate-current dynamos.** Gisbert Kapp, 70, Market street, Manchester.

17348. **Improvements in electrical transformer street surface boxes.** Henry White Bowden and William Boby, 16, Union court, Old Broad street, London.

17352. **Improvements in electrically controlled arc lamps.** Frederick Thomas Schmidt, 9, Clarendon street, Bradford.

17372. **Improvements in magneto-electric motors.** Henry Ludeke, Ernest Louis August Ludeke, Arthur James Thorman, Ernest de Bunsen, and Edward Madge Hore, 4, St. Benet place, Gracechurch-street, London.

SEPTEMBER 16.

17445. **Improvements in pipe conduits for electric mains.** William Harding Scott, Gothic Works, King street, Norwich.

17466. **Improvements in the treatment of zinc produced by electrolysis.** William Wright and John Brumfield Hamond, 1, Quality-court, Chancery-lane, London.

17493. **Improvements relating to thermo-electric batteries and to apparatus for use in the manufacture of the same.** Jean Baptiste Charles Dion, 45, Southampton buildings, Chancery lane, London.

SPECIFICATIONS PUBLISHED.

1892.

15318. **Electrical transformers.** Leigh. (Apollonj.)

15137. **Electrical contacts.** Gray and Price.

15689. **Relays for electric telegraphs.** Willot.

16768. **Switching telephone, etc., exchanges.** Pippette.

17092. **Insulating and supporting electric wires.** Crompton and Dowsing.

18847. **Field magnets and armatures of current electro-motors, etc.** Joel.

18994. **Electromagnets.** Timmis.

1893.

7848. **Indicating telegraphic messages.** Levi.

14210. **Telegraph posts, etc.** Siemens Bros. and Co., Limited, and May.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
City of London	—	11
Pref.	—	12¾
Electric Construction	—	—
Gatti's	—	5¼
House to House	5	5⅜
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	6½
National Telephone	5	4¾
St. James, Pref.	—	8
Swan United	3¾	3¾
Westminster Electric	—	5½

NOTES.

New Boat.—An aluminium ferry-boat has been launched at the Quai d'Orsay, Paris.

Telephony.—Various subscribers to the telephone in Glasgow are complaining of the cross-talk on the lines.

Dirigible Torpedoes.—Experiments are to be made next month by the Royal Engineers with the Brennan dirigible torpedo.

Cheap Current.—Current is now being supplied for motive power purposes from the Cologne municipal station at 3d. per 1,000 watt hours.

Obituary.—The death has just taken place at Folkestone of Mr. Henry Weaver, the managing director of the Anglo American Telegraph Company.

Madras Tramways.—An extension in the time for constructing the electric tramway has been granted. A local board of directors is to be appointed.

Lighthouse.—Mr. Passmore Edwards has intimated his intention of erecting a lighthouse on the St. Agnes Beacon, which will be lighted by electricity.

Danzic.—The General Electricity Company, of Berlin, have entered into a provisional agreement for the working by electricity of the five tram lines in this town.

Branch Societies.—Proposals are under consideration in the United States for the establishment of branch societies of the American Institution of Electrical Engineers.

Siam.—The Siamese Government Telegraph Department has profited greatly by the abundance of the telegraphic messages recently sent between Paris and Bangkok.

Lightning.—The parish church of Misson, on the boundary of the county of Nottingham, was struck by lightning on Saturday, and a great portion of it was completely destroyed.

British Association.—The meeting next year will be held at Oxford, and not at Ispwich, as mentioned in our last issue. The meeting in 1895 will, however, take place at the latter town.

Cardiff.—Councillor Jenkins suggests that the Town Council should acquire the tramways. If the proposal is entertained, the municipality might be disposed to consider electric traction.

Society of Engineers.—The next ordinary meeting will be held at the Town Hall, Westminster, on Monday next, when a paper will be read on "Gas Substitutes" by Prof. Vivian B. Lewes, F.I.C.

The Douglas Tramway.—This electric tramway, to which reference was made in a recent issue, has been started as far as Crowdle Glen. It will eventually be extended to Laxey, a distance of seven miles.

Traction in Vienna.—The Austrian Ministry of Commerce have been approached by the General Electricity Company, of Berlin, with a view to undertaking preliminary technical steps with regard to several electric lines in Vienna.

False Fire Alarms.—Notwithstanding the fact that Parliament has recently given magistrates the power to fine any person giving a false alarm to the firemen the heavy sum of £20, false "calls," by means of the alarm posts, continue to be given in London with great persistency.

Light Electric Vehicles.—Experiments are being made in Italy with light electric vehicles somewhat larger than ordinary tricycles. The vehicles are equipped with a battery of 10 cells weighing about 3cwt., and capable of yielding sufficient energy to propel them for from three to five hours.

The "Nile."—This new Royal Mail steamer is lighted by electricity. The generating plant is in duplicate, there being two high-pressure engines coupled direct to dynamos running at 210 revolutions and giving a current of 165 amperes at 100 volts. There are 500 lamps installed in the ship.

Antwerp.—The work in connection with lighting the town by electricity has commenced. A London company have secured the contract for laying about 11 miles of mains, and a staff of English engineers is superintending the laying of the mains. It is calculated that about six months will be required to complete the contract.

The Proposed Berlin Electric Railways.—It is stated that the Imperial Government has approved of the schemes prepared by Messrs. Siemens and Halske for the construction of three elevated electric lines in Berlin. The gauge will be 4ft. 8½in., and the cars will be mounted on two trucks, each being equipped with an electric motor.

Southampton.—The docks have just been equipped with an electric light installation for the London and South-Western Railway Company. The low-tension system has been adopted in conjunction with accumulators, the current being distributed by means of feeders to a three-wire system of mains. Both arc and incandescent lamps are used.

Traction at Wolverton.—Electric traction engineers should bear in mind the Wolverton and Stony Stratford District New Tramways Company, Limited, which has been registered with a capital of £5,000 in £100 shares, to acquire the undertaking of the Wolverton and Stony Stratford and District Tramways Company, and to extend its operations.

Science and Farming.—Lord Rayleigh has notified the villagers in the immediate neighbourhood of his Essex seat, Terling Place, near Chelmsford, that anyone wishing to hire land for farming purposes can have from one to four acres, at 25s. per acre. The usual price per acre for the hire of allotment land in Essex ranges from £2 to £4 and in some cases to as much as £6 per acre.

The Tramways Institute.—Mr. J. G. B. Elliot, the secretary of the Tramways Institute of Great Britain and Ireland, informs us that the meeting proposed to be held at the Isle of Man on the 4th and 5th October has been abandoned in consequence of the very small number of members who would be able to attend. There will, therefore, be no general meeting of the institute that month.

Cheaper Telephony Wanted. — The Sonneberg Chamber of Commerce, supported by other similar institutions, has approached the German postal authorities with a view to getting reduced the annual subscription to the telephone. In reply, Herr von Stephan has intimated that, instead of being able to grant a reduction, an increase in the rates may be expected, at least for inter-town communication.

Train-Lighting.—A welcome improvement is being introduced on the carriages of the District Railway. Instead of the one ordinary gas lamp in the centre of the roof of each compartment, there are being installed four incandescent lights fixed in the four corners of the compartment immediately over the passengers' heads. An experiment has previously been made with the electric light, which is very satisfactory.

Railway-Office Lighting. — The Great Northern Railway Company on Saturday evening introduced the

electric light for the first time in connection with all the departments at King's Cross. There are altogether 144 offices which have been electrically equipped. The work of lighting Holloway and Finsbury Park Stations is being rapidly pushed forward, and is expected to be brought to completion in a few weeks.

Coast Communication.—The Post Office authorities have decided, and the work is now in progress, to lay a cable from the Gunfleet Lighthouse to the old Gapway at Frinton, near Walton-on-the-Naze, as the first portion of the telephonic communication between the various lighthouses and vessels on the east coast and the coastguard stations at Harwich, Walton, and Clacton, all three of which will be connected by a land wire.

Insulation Resistance. — The Société Française d'Encouragement pour l'Industrie Nationale offers a prize of 2,000f. (£80) for the construction of an apparatus or the discovery of an industrial method allowing of the rapid measurement of the insulation resistance of different parts of an installation in operation. The prize will be awarded in 1895. Any further particulars may be obtained of the secretary of the society, 44, Rue de Rennes, Paris.

The New Portable Lamp.—We referred last week to the new portable lamp devised by Mr. Max Sussman, and described by Mr. Doubleday at a meeting of the North Staffordshire Mining Institute, at Stoke-on-Trent. In reply to questions, Mr. Doubleday said that none of the lamps had been brought into use in mines. A great many had been and were being tested, and the reports, some of which he read, were favourable to the lamp. The lamp would not be of service as a gas-detector.

The Phonograph.—Automatic machines in connection with the Edison phonograph are said to be fixed at the railway stations in the United States. Thus by putting a penny in the slot and applying the ear pieces of the instrument to the ears, travellers, while waiting for their trains, may enjoy the strains of some popular singer at the opera or concert hall, listen to some passage of a speech in the voice of a prominent orator, or hear a few verses of poetry as recited by some prominent person.

Govan Tramways.—A Board of Trade enquiry has been held in connection with the application of the Town Commissioners for sanction to borrow £60,000 to liquidate the price of the tramways, which were recently taken over by the burgh. Mr. Duncan, of the Glasgow Tramway Company, in reply to questions, said that there was no immediate prospect of the system being worked by mechanical power, and that when it could be proved that electricity was cheaper, they would certainly adopt it, but not until then.

Elmore Copper.—The title of the company which M. P. E. Secrétan is forming in Paris for the acquisition of the Dives works and other assets of Elmore's French Patent Copper Depositing Company, and which had already been acquired by the former from the receiver and manager of the latter, almost takes away one's breath. It is the "Société Française d'Electro-Metallurgie pour la Fabrication du Cuivre et autres Metaux par les procédés Elmore et Secrétan." The objects of the company will be readily understood, but what is implied by M. Secrétan's process?

New Catalogues.—A copy of their illustrated catalogue of electrical fittings and fixtures has been forwarded to us by Messrs. Paterson and Cooper. We notice various kinds of artistic electroliers, billiard fittings, brackets, drop pendants, ceiling fittings, table standards, etc. The same firm send us a copy of their catalogue of switches and switchboards, cables, fuses, casings, etc.; a list of the Phœnix five-ampere arc lamp, which has been designed to meet the demand for a reliable small current lamp; a list of measuring instruments for direct currents; and one referring to the Phœnix direct-current dynamos.

Working Lock Gates by Electricity.—A system devised by Mr. Munro for opening and closing the lock gates of canals by electric power has been tested on the Beauharnois Canal. The experiment was entirely successful, and demonstrated the advantages of electric motors for this purpose. The gates were easily closed or opened by the motors in about one minute, an operation which takes four men three or four times as long to accomplish by hand. As a result of this trial, electric power is to be adopted for the lock gates of the nearly completed Soulanges Canal on the St. Lawrence River, some 30 miles above Montreal.

Cheap Telephony for the City.—The Commissioners of Sewers will no doubt be pleased with the suggestion made by Mr. H. S. Foster, M.P., who asked the former on Tuesday to pass a resolution in favour of his seeking for a license from the Postmaster-General to establish a first-class double-wire telephone service in the City at a maximum charge of £8 per annum. The matter has been referred to the Streets Committee. The same committee had referred to them a circular letter from Mr. R. Starke, convener of the Telephone Committee of the Glasgow Corporation, in the memorandum regarding the contract being negotiated between the Post Office and the National Telephone Company, relating to the telephone system.

Incandescent Lamps.—As will be seen from our advertisement columns, there is a great preparation going on in the matter of making incandescent lamps in view of the lapse of patents next November. The Brush Company are pushing their plans with energy, and will manufacture lamps at their own works under the most improved and modern processes. Having other works, the Brush Company did not require the lamp factory at Hammersmith, and we understand this factory is now in the hands of the General Electric Company, which company is pushing forward the plant to enable it to get an output of over a million lamps per annum. The management of this factory will be in the hands of Mr. C. J. Robertson, who has had considerable experience both in England and on the Continent.

Telegraphic Communication. — The Associated Chambers of Commerce adopted on Wednesday the following resolution submitted by the Wakefield Chamber: "That in the opinion of this association it is unfair to the public that the telegraphic department of the Post Office should for financial purposes be treated as a separate establishment, thereby causing unwarrantable delay in carrying out urgent and much-needed reforms; that inasmuch as the postal establishment and its various departments are in their entirety a financial success, the time has arrived when the address of not exceeding six words should be allowed free of charge in all telegraphs, and that telegraphic communication should be extended to rural districts where practicable, and that a deputation wait upon the Postmaster-General to urge upon him the desirability of adopting this suggestion."

How to Show Lines of Electric Force. — The following experiment for making visible lines of electric force is described by Herr Bruno Kolbe: "Into a flat cylindrical vessel pour purified anhydrous oil of turpentine to a depth of about 2cm., and add some sulphate of quinine. To the rim of the vessel attach two wire springs, adjusted so that the two small metallic balls at their ends dip into the turpentine. Stir the quinine with a glass rod so as

distribute it evenly, and place the vessel on a black cardboard. Join the two wires to the terminals of an influence machine, and turn very slowly. At once the white crystals group themselves so as to form beautiful curves, representing the 'lines of electric force.' The form of these curves recalls that of the brush discharge of the influence machine. Prof. Weiler, of Esslingen, gives the following experiment: Prepare a milky mixture by stirring up finely divided quinine in oil of turpentine. On sending a series of discharges through it, a clearance is produced at the positive pole, and the particles cluster round the negative pole, arranging themselves in streamers directed along the lines of force."

Electricity for Heating Purposes.—The London correspondent of a provincial paper states that it is often said of gas companies that their profits are safe, because, although electricity may be the light of the future, gas will always be a source of revenue for the production of heat and power, but he remarks electric heating is being rapidly developed. Some of the London supplying companies are ordering electric cooking stoves to be lent out to consumers, as gas stoves are by the gas companies, and what is of greater importance, continues the correspondent, is that the electrical compenies are prepared to supply a separate meter and charge half rates for cooking, which they can afford to do, inasmuch as the consumption takes place during the day when the dynamos must generate electricity, and when there is little demand for it for lighting purposes. Besides these ovens there are breakfast cookers, in which eggs and bacon may be cooked on the breakfast table; electric plate-warmers, which are being ordered for London clubs, for they can be kept in the dining-room without any offensive smell as in the case of gas; electric foot-warmers, hot-plates, stewpans, saucepans, kettles, flat-irons, ornamental screens which act as radiators of heat and warm a room, electric curling-iron heaters for ladies, and electric shaving-pots for gentlemen.

Lightning Express Railway Service.—In a letter to the *Times* of yesterday, Mr. F. B. Behr, whose express railway service was referred to in a previous issue, states, in regard to the ventilation of the carriages: "The carriage is lighted by sheets of plate glass, which are fixtures, and is divided, as shown in my pamphlet, into two halves placed on either side of the central rail, leaving a sort of tunnel between these two halves. The tunnel is hermetically closed at the end facing the direction in which the carriage travels, but it is open at the back. It is, therefore, always filled with a column of air which is practically stationary. This air communicates with the bottom of the carriages and escapes at the top by an aperture inclined in the direction opposite to that in which the carriage travels, so that the foul air can freely escape. Thus the carriage will be effectually ventilated without the necessity of windows being opened, and at the same time the column of air in the carriage and tunnel is entirely uninfluenced by the rapid travelling of the carriage, though constantly replenished without any perceptible movement. This leads me to point out that the necessity for placing passengers lengthways and parallel with the rail in any carriage travelling at such a rapid speed, and the necessity for providing a tunnel in the centre of the carriage for purposes of ventilation, as above described, would always necessitate the adoption of a form similar to that of a single-rail Lartigue carriage, even on the ordinary system of railways, and this seems to me an additional proof of the advantage of building such lines on the single-rail system, as I propose."

The Manchester Station.—The five-wire system was brought into operation on Monday, when some 10,000 8-c.p. lamps in the centre of the city were energised. That occasion was not the first on which current had been supplied from the new station in Dickenson-street, because since the end of July there has been, as mentioned in our issue of the 8th inst., a night service between the hours of 5 p.m. and 12 p.m. to certain consumers. The change from the simple parallel system to the five-wire system took place on Saturday night. After the transformation a number of large halls and public buildings were switched on, and on Monday the leading tradesmen whose premises had been connected with the electric mains enjoyed the full benefits of electrical illumination. The Manchester Corporation now has several hundred lamps in the Town Hall, and a large number has been fitted in the Council-chamber, the large hall, etc., which was inspected by the Lord Mayor and members of the Council this week. The total cost of the station, its site, and the appliances will amount to £150,000. One hundred thousand pounds was the original sum, and £70,000 has already been expended, but it is the intention of the City Council to apply for power to spend another £80,000 in extensions which are deemed necessary as the demand for the supply increases. The main building in which are fixed the engines and dynamos is an extensive hall divided into two bays. At present there are two large vertical compound engines of 400 h.p. fixed, and two more similar ones in course of erection. Besides, there will be six other engines of 100 h.p., with the corresponding dynamos. The engines are at present supplied from six boilers of the Lancashire type, with mechanical stokers and economisers.

Electric Lighting in Sheffield.—Some important extensions are now in progress in this town, where the electric light was first introduced about 12 years ago, and very soon the plant being laid down will be capable of supplying 150,000 lamps. The central station is in process of construction in Commercial-street, and transformer stations have been erected in various parts of the town. There will be eight sub-stations, and current will be transmitted to them at a pressure of 2,000 volts. The high-tension system has been adopted on account of the large area to be dealt with—an area which includes every part of the town. As soon as the underground work in connection with the compulsory area is complete, the company will proceed to extend the system to the Broomhill and Ranmoor districts, where a large demand for the current is anticipated. At present the work connected with the reconstruction of the central station is being vigorously proceeded with. Five Babcock and Wilcox boilers have been already put down, and two additional engines and alternators, manufactured by the Brush Company, are being erected. At the central station there is a number of Mordey-Victoria alternators working at a pressure of 2,000 volts. These are rope driven from high speed vertical engines. Effective arrangements have been made for dealing with cases of emergency. Duplicate engines are provided, the company having decided to have a certain percentage of spare plant ready for use when needed. The supply of current is made at present from overhead wires, but the conductors which will supply the town under the new scheme will pass underground. The mains have been laid on the Callendar's bitumen system. The applications for current are numerous, and new and old buildings are being wired in anticipation of the supply of current.

Electric Motive Power.—We have from time to time drawn attention to the increasing employment of electric motors for operating machinery—one of the most complete installations of such being that in the works of the Electric Construction Company at Wolverhampton. Whilst, however, the energy utilised in the

latter instance reaches at the very utmost one or two hundred horse-power, we shall at an early date be able to give full details of plant and machinery in an important manufacturing centre driven entirely by electric motive power, each individual machine or appliance being worked by a separate motor, where the total energy employed will reach a maximum of some 11,000 h.p. The material for this installation is now being shipped from this country, and on its erection the results obtained from daily working will doubtless be looked for with a considerable amount of interest, since waterwheels are to be employed for driving the dynamo generators, and the power station therefore is no insignificant rival to that now being erected at Niagara Falls. The mills wherein the electric motors are to be placed chiefly will engage in jute manufacture: and no shafting of any kind will be used in them. The following details have already been published in the *Mexican Trader* concerning the enterprise: "Mr. Thomas F. Kinnel, the holder of a concession for the establishment of jute factories at Orizaba and elsewhere, has already secured the capital necessary for the erection of the first factory, which will be situated at Barrio Neuvo, Orizaba. The shares, amounting in the aggregate to £100,000, have been placed in London. The foundations of the factory have been dug, and those for the house are being prepared. Work on the canal and tunnel is progressing, and both will shortly be finished. The waterfall is a very fine one, its force equalling 11,000 h.p., with a fall of 115ft. The factory is situated 1½ miles away from, and some 600ft. above the level of, the wheelhouse. Pelton wheels will be exclusively used to drive the machinery through the intervention of electric generators and separate motors. The head-race will be 321ft. in length, the water being conveyed in pipes to the wheelhouse. Four generator dynamos will be used, and every machine in the factory will have a motor of its own, ranging from 1 h.p. to 20 h.p. The whole of the electric plant has been ordered in England, and has been made specially for the work. The buildings are to consist largely of corrugated iron upon iron framing, since the fact that no belting or shafting will be used enables solid masonry to be dispensed with. The contractors for the work are: spinning machinery, Fairbairn, Naylor, Macpherson, and Co., Leeds; weaving machinery, Robertson and Orchar; finishing machinery, Thomson, Son, and Co. The electrical engineer is Mr. A. H. Wood, A.I.E.E., London. The head office is in London, and Mr. James K. Prain is the Dundee representative."

Experience of Electric Traction.—One of the questions discussed at the recent tramway congress held at Budapest, and to which reference was made in previous issues, was very important. It was as follows: (*a*) Have you investigated or had experience in electric haulage, and with what results? (*b*) Under what conditions does it appear to you that electric traction deserves the preference over that of animal or mechanical hitherto used? Some of the remarks made in reply to this will prove of more than usual interest. Mr. Noonenberg mentioned, as is well known, that the working expenses of the Julien accumulator cars experimented with in Brussels for three years, were higher than those incidental to horse cars. Storage-battery cars, as shown by the Frankfort tramway, worked so faultlessly that they would not be rejected by any town; but the financial results were still questionable. The speaker said that the circumstances which had until recently operated adversely to the development of electric tramways in Europe were of various kinds. It was in the first instance thought that the authorities *would not permit* the erection of standards in the streets, and that therefore the companies would be compelled to adopt an underground conductor or the accumulator system. It could, of course, not be doubted that the method of working the overhead system was the most satisfactory. Another difficulty in the way of the adoption of electric power was met with in the case of the tramway companies, who did not wish to be burdened with the considerable expenditure that would be necessary in converting their systems. There was, continued Mr. Nonnenberg, no basis of working expenses in the case of the European electric lines, and upon which the tramway companies could rely as an important factor, and each line had to stand on its own merits in calculating the working expenses in any town. On the conclusion of these remarks, Mr. Hippe, of Munich, who is connected with a steam and horse tramway company, observed that a transformation from one method to an electric system could only be effected provided a satisfactory guarantee was given as to financial success. The question arose, what were the costs of the different powers? According to the reports of the "electricity company," whatever that may mean, the haulage expenses per car mile with horses cost 3d., and with electricity 1½d. per car mile. The difference between the two amounts only rendered possible a conversion from one system to another commercially successful in the most rare cases, and in the greater number of instances the increase in the capital expenditure would certainly diminish the interest on the original capital. For the present Mr. Hippe believed that it was too early to change from a horse system to electric traction, although in the long run electricity would dominate as the motive power on tramways. When that time arrived no one would hesitate about the conversion. Mr. Kruger, of Hanover, referred to the working of a tramway in Hanover, where during a half-year's operations a loss of £400 had occurred. That line was then transformed into an electric tramway, and since then the condition of affairs had changed, the rapidity of the service having quadrupled the receipts. One condition for the prosperity of electric lines was the granting of permission to run the cars at tolerably high speeds. The conversion was of course in a certain measure a leap in the dark, and therefore special care must be taken on a change from one to the other, so that the local authorities not only did not increase the burdens on the enterprise, but, on the contrary, extended the period of the concession and granted certain advantages to the line, otherwise a return on the high costs of transformation would be impossible. Mr. Röhl, of Hamburg, laid stress upon local circumstances, and opined that it would be useless to change a system when the concession was only for 15 years. With regard to Hamburg, an electrical firm had guaranteed that the working costs of the line should be 25 per cent. cheaper than with the existing system, and the speaker said that a conversion was only to be recommended when a firm would undertake to guarantee their estimates. Director von Jellinek expressed the opinion that the figures available as to financial results were mostly only approximate, and from them no definite decision could be taken. Mr. Hamspohn, of the Union Elektricitäts Gesellschaft, said that in America the local authorities furthered electric traction, since it not only facilitated transit, but also had a sanitary effect. After further discussion a resolution was passed stating that the available data with regard to the working expenses of electric tramways were not yet sufficient to allow of a judgment being formed from a financial point of view, but that electric traction was desirable in the public interest.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

DISTRIBUTION OF ELECTRIC POWER.

(Continued from page 247.)

Fig. 29 shows a number of dynamos working into a three wire system, and also how secondary or storage cells are used in conjunction with the dynamos. The method of connecting the dynamos and cells is that usually adopted in central station practice for three-wire systems. As the load increases, another dynamo is switched into parallel, as on the two-wire system. There are three machines shown in parallel in Fig. 29, all working at a pressure of 220 volts. The cells serve two purposes—first, they steady the supply, discharging a current when the load makes heavy demands, thus easing the sudden strain on the dynamos; and absorbing current from the dynamos when the load suddenly falls, thus replenishing the electric energy in the cells, so they may be looked upon somewhat as a "reservoir." Two batteries of cells are used, *b* and *b*¹. These are joined in series across the positive and negative mains, A and B, the third wire,

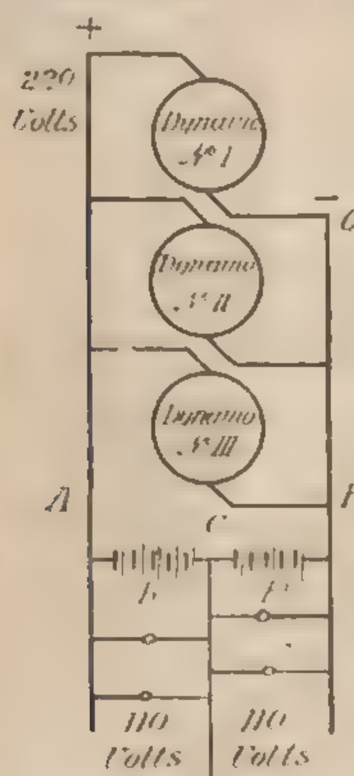


Fig. 29.

C, being run from the junction of *b* and *b*¹; so when the load on the + side is greater than the load on the – side, the battery *b* assists the dynamos. On the other hand, when the load on the – side is greater than that on the + side, then battery *b*¹ assists the dynamos. So far, the third wire is not connected up to the dynamos in any way, and in the case where feeders are used, as in Fig. 28, the third wire is laid down from the feeding centres, thus saving a considerable weight of copper by not taking it back to the generating [illegible]

The original use of the third wire, as invented by Dr. John Hopkinson in 1882, was obtained by coupling together two similar dynamos in series, the + and – cables being connected to the outer + and – terminals of the set, while the third or middle wire was connected to the junction of the inner + and – terminals. The advantage of thus taking the third wire back to the dynamos is that it enables the surplus current to return to the dynamos when the load is greater on one side of the system than on the other side. It need hardly be said that in connecting up lamps on a three wire system it is necessary, as far as actual practice will permit, to arrange the lamp circuits so that the whole of the supply or load is as nearly equally divided as possible—that is, to have as much current taken off the + and third wire as off the – and third wire. When the load on the + side is greater, say, than that on the – side, the difference between the two currents is called the "differential current," and this current will flow along the third wire back to the dynamo on the + side, because that dynamo is working at a greater load than the other. If the – load were greater than the + load the differential current would flow back along the third wire to the dynamo on the – side, and when the loads on both sides are exactly equal then there is a balance and no current flows along the third wire, because the + and – sides are then just as if there were no third wire and they were in simple series. From this the third wire is often called the "balancing wire."

The next development of the parallel systems is found in the five-wire system, and as the three-wire permitted double the pressure that was used in the simple parallel, and hence an extension of area, so the five-wire system permits double the pressure that is used in the three-wire system, and hence a still further extension of area. In this system the dynamos work at, say, 400 volts, three wires being placed between the two outer wires, thus

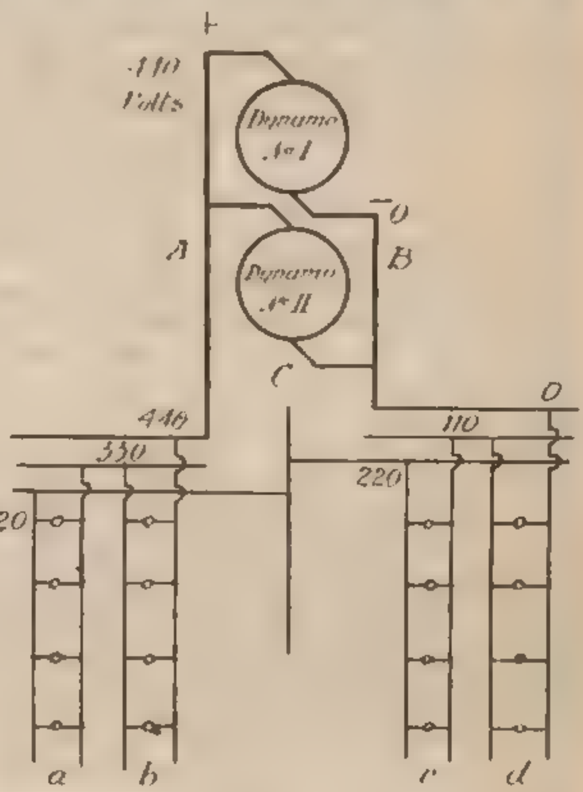


Fig. 30.

making five wires altogether. Lamp circuits requiring 100 volts or so can thus be taken off any two neighbouring wires out of the five; if 200 volts is required, the circuit is taken off any two alternate neighbouring wires; if 300 volts be required, it is taken off, say, the outer + main and the fourth wire and so on. There are thus four circuits of 100 volts in the five wires taken respectively off the + main and the second, the second and the third, the third and the fourth, and the fourth and the – main. Every circuit must have some lamps connected on, and these should as far as possible be distributed equally between the four circuits so as to obtain an equalised load, so in reality these four circuits are all in series, and so make up the 400 odd volts that exist between the two outer cables

Parallel systems are mostly designed for 110 volts pressure at the distributing centres, because 105-volt lamps are mostly used, and the other five volts is a margin for fall of pressure This explains why in Fig. 29 the dynamos are of 220 volts, and the two circuits of 110 volts each; hence in the five-wire system the dynamos are worked usually at 440 volts, giving four circuits of 110 volt
In Fig. 30 the five wires are not all kept
out the supply district, but the diagr

sent the method of supplying two districts that are close together, and both a little distance away from the central station. Two dynamos of 440 volts pressure are shown in parallel—A is the positive cable, and B is the negative; and on account of the pressure being much higher than a simple parallel system, the current flowing through them is much less, and consequently the size and weight of the cables are considerably less, which is a matter of paramount importance when distance has to be considered. When they reach the two districts to be supplied, a third wire, C, is introduced, the + cable and the third wire, C, supplying one district, whilst the negative cable and the third wire, C, supply the other district. We have now a pressure of 220 volts in each district, and again a third wire is added, one to each district, thus making a total of five wires in all, each being at different pressure. In the left-hand district two lamp circuits can now be taken, each of 110 volts. Circuit *b* being taken from the middle wire and A, A is at a pressure of 440 volts, the middle wire will have a pressure of 330 volts, and the difference is 110 volts. Similarly, circuit *a* takes the difference between the middle wire and C, that 330 – 220 = 110 volts as before.

Passing along to the right-hand district, we can in a similar way take off two more circuits, *c* and *d*, each having 110 volts, the last circuit, *d*, taking the difference between 110 and 0 = 110, so that the circuits and their lamps are all in series between A and B, and thus have a working pressure of 440 volts. Great flexibility of distribution can thus be obtained from the use of a five-wire system; it is certainly complicated, particularly when the five wires are carried up to the lamp circuits, and on that account, together with the extra expense in dealing with such complications, is at a disadvantage as compared with simple parallel wires of a high-pressure alternating current.

When feeders are used in the five-wire system they are connected to the two other wires, there being three intermediate wires, so that in Fig. 28, if the middle wire were replaced by three wires, and the pressure of the machines changed from 200 to 400 volts, that would give an illustration of this method of supply.

The loss or waste of electric energy along a pair of mains is a very different thing from the mere loss or fall of pressure, and careful distinction must be made between the two, because the latter depends simply on the current and the resistance of the mains, denoted by C R, while the former depends on the square of the current and the resistance, denoted by C^2 R. We will now investigate what results are obtained when a pair of mains, or feeders, undergo various conditions of working whilst the electric power received by them remains the same, it being assumed that none of the electric power is used along the mains, but the whole of what is transmitted is utilised at the far end of the mains, so that the cables under consideration may be looked upon really as "feeders."

The following will be assumed as the initial or normal condition of things: The feeders have a sectional area of one square inch each, a distance of 200 yards (200 yards positive and 200 yards negative), and a current of 400 amperes flows through at an initial pressure of 100 volts; hence the current density is 400 amperes per square inch, and the electrical power delivered by the dynamo into its end of the feeder is $100 \times 400 = 40{,}000$ watts, or 40 kilowatts. The resistance of such a pair for the above distance of 200 yards may be put down at ·01 of an ohm—that is, one-hundredth of an ohm, being at the rate of ·044 ohm per statute mile when taken at the temperature of 60deg. F., or 15·5deg. C. The increase of resistance due to the current may be neglected, because it is only very small with a low current density of 400. The total weight of copper in both feeders for this distance is 2·08 tons, or 4,660lb. To force 400 amperes through ·01 of an ohm resistance requires $\cdot 01 \times 400 = 4$ volts, so that the pressure at the farther end of the feeders will be 96 volts, two volts being lost in the positive feeder and two in the negative, hence the total fall of pressure is 4 per cent. We can now calculate the loss of energy in the feeders by multiplying the fall of pressure by the current. This is the same thing as multiplying the line resistance by the square of the current, because $C^2 r = C e$, where $e = C r$ = fall of volts. Applying this to the above case, we have 4×400, or $(400)^2 \times \cdot 01 = 1{,}600$ watts. The total energy delivered to the feeders is 40,000 watts, the quantity received at the end of the line is 38,400 watts, so that the loss of energy = 4 per cent. Doubling the pressure and using the same current density, the same power can be transmitted double the distance for the same percentage of fall of pressure or loss of energy; so with 200 volts pressure, the feeders need only have a sectional are of ·5 square inch each, and the current of 200 amperes can thus be driven 400 yards.

It is evidently very clear that when the percentage of fall of pressure or loss of energy must be confined to certain low limits, it is absolutely necessary to employ small currents of high pressure in order to transmit or distribute electric power over long distances or scattered districts.

To show at a glance how the loss varies under different conditions, Tabulation 29 is prepared, the electric power delivered in every case remaining constant—viz., 40 kilowatts. The three most important variables being (1) pressure, (2) distance, (3) current density, when these are known the rest can be found.

TABULATION 29.

Pressure in volts.	Distance in yards.	Current density per square inch.	Area of cable in square inch.	Weight of copper in tons.	Total pressure lost.	Percentage of loss.	
						Pressure.	Energy.
100	200	400	1·00	2·08	4	4	4
200	200	200	1·00	2·08	2	1	1
200	400	200	1·00	4·16	4	2	2
200	200	400	·50	1·04	4	2	2
200	400	400	·50	2·08	8	4	4
400	200	400	·25	0·52	4	1	1
400	400	400	·25	1·04	8	2	2
400	800	400	·25	2·08	16	4	4
800	800	400	·125	1·04	16	2	2
800	1,600	400	·125	2·08	32	4	4
1,600	1,600	400	·0625	1·04	32	2	2
1,600	3,200	400	·0625	2·08	64	4	4

Comparing together the first and the last, it is seen how enormously the distance can be increased by using high-pressure currents, the loss being the same, the weight of copper being the same.

From these figures several useful rules can be obtained:

(1) With current density and distance constant, percentage of loss is ∝ inversely to pressure.

(2) With current density and percentage of loss constant, distance is ∝ to pressure.

(3) With current density and pressure constant, percentage of loss ∝ distance.

(4) With distance and percentage of loss constant, current density ∝ pressure.

(5) With distance and pressure constant, percentage of loss ∝ current density.

(6) With pressure and percentage of loss constant, distance is ∝ inversely to current density.

(To be continued.)

ON STANDARDS OF LOW ELECTRICAL RESISTANCE.*

BY PROF. VIRIAMU JONES.

The preparation of standards of low electrical resistance of from ·001 to ·0001 ohm seems to be a matter of some importance at the present time. These standards are already in request among engineers, and it becomes of interest to consider how they may be best measured to a percentage accuracy comparable with that with which the standard ohm is known.

Such standards of low resistance may be derived by potentiometer methods from the standard ohm by a series of downward steps. But this is, from one point of view, roundabout. The method of measuring the ohm that seems in all its details most accurate is that of Lorenz. In this method the ohm itself is derived from the measurement

* Paper read before the British Association.

of a small resistance. It is simply going up and down again to prepare from the ohm so derived the required small resistance standards, and it is more direct and more accurate to measure the latter directly in absolute measure.

In Lorenz's method a metallic disc, Fig. 1, is made to rotate in the mean plane of a co axial standard coil. Wires touching the centre and circumference of the disc are led to the ends of the resistance to be measured, and the same current is passed through this resistance and the standard coil. The connections being rightly made, we may, by varying either the rate of rotation of the disc or the resistance measured, so arrange matters as to have no change of current in the circuit of the disc and wires joining it to the ends of the resistance, when the direction of the current through the resistance and the standard coil is changed. When this arrangement is effected, there is a balance between the E.M.F. due to the motion of the disc in the magnetic field of the current in the standard coil and the difference of potential at the ends of the resistance, due to the current traversing it. If this adjustment be made, we will say that the apparatus is in an equilibrium position.

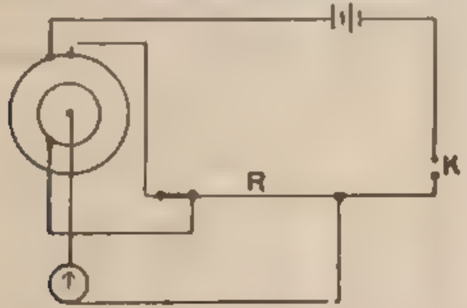


FIG. 1.—Lorenz Arrangement.

If M = coefficient of mutual induction of the standard coil and the circumference of the disc;
n = the rate of rotation of the disc (number of revolutions per second);
R = the resistance;
γ = the current through the standard coil and the resistance;

then in an equilibrium position

$$M n \gamma = R \gamma, \text{ or, } R = M n.^*$$

I do not think that electricians have as yet realised the accuracy and ease with which absolute measurements of resistance may be made by this method.

First let us consider accuracy. The absolute measurements involve measuring, first, the coefficient of mutual induction of a standard coil and the circumference of the rotating disc, and, secondly, the rate of motion of the disc. Now it lies well within the resources of modern mechanical engineering to make a standard coil and disc of dimensions known to an accuracy considerably greater than 1 in 10,000, the coil being constructed of a single layer of wire wound in a screw thread cut in a cylinder of large diameter, and the measurement of the rate of motion to equal accuracy is a simple matter. There is difficulty in maintaining a rate of rotation constant to this figure for four or five minutes, but with the closest attention to the lubrication of all the bearings this also might be accomplished. Such constancy is well worth striving for, as the ease with which measurements of resistance can be made by the method largely depends upon it, and this brings me to the second point I mentioned—viz., the facility with which accurate measurements may be made with a well-constructed Lorenz apparatus.

I do not propose on this occasion to enter into the details of the method I have adopted in making the measurements, the results of which I have presently to bring before the section, but it will be perhaps of interest if I say a word or two about the time measurement.

In measuring a resistance we have to find the rate of rotation corresponding to an equilibrium position. It is easiest in practice to determine this by interpolation from two determined rates of rotation (near together, and respectively slower and faster than the required rate), and the galvanometer deflections corresponding to them, so that each determination of resistance involves no determination of galvanometer deflection and of the rates of rotation corresponding to them.

* *Phil. Trans.*, 1891, Ap. 2.

In order that the galvanometer deflection may be obtained with sufficient accuracy from a limited number of reversals (in my observations the number has been almost uniformly 33, taking about four minutes in each case), the brush at the circumference of the disc needs to be perforated and to be supplied with a constant stream of mercury. Such a brush in its best condition almost entirely eliminates the continual jerking of the galvanometer needle, consequent in thermo electric changes at the point of contact of brush and disc. A multiplication of such brushes at three or four points of the circumference would do this more completely.

During the four or five minutes' run, the rate of rotation is referred by a stroboscopic method to a suitable tuning-fork provided with riders maintained in vibration electrically. The observer at the fork can shunt more or less current through the electromotor driving the disc, and in this way maintains the rate of rotation as constant as he can. But though the electrically-maintained fork is useful for purposes of control, it cannot be relied on to give us the rate of rotation. Its vibration period is not, within my experience, constant to the degree of accuracy required. If stopped and set going again it may start with a period difference by several ten-thousandths. No previous determination of the period of the fork could, therefore, be relied on to give us the rate of rotation, though once started the fork goes sufficiently uniformly to give us a means of control.

Accordingly it is necessary to measure the rate of rotation during each run while the galvanometer observations are being made. The rotating disc is, therefore, by means of an eccentric attached to its axle, made to record its revolution on the lapse of a Bains electro chemical telegraph instrument side by side with the record of the standard clock. We have then a time record exactly corresponding to the period of observations of the galvanometer deflecting. During the run, then, we have simultaneously the observer at the galvanometer calling out the galvanometer deflections, and the observer at the tuning-fork controlling the speed, while the Bains instrument records it.

I have made in this way a number of measurements during the months of July and August of a standard resistance approximately ·0005 ohm, prepared last year by my assistant, Mr. Harrison, and a student in my laboratory, Mr. Parker, with the following results:

July 17, morning	·00050016
,, ,, afternoon	·00050016
,, 19, morning	·00050015
Aug. 2, afternoon	·00050020
,, 3, morning	·00050021
,, 4, morning	·00050016
,, 4, afternoon	·00050013
,, 5, morning	·00050019
,, 9, morning	·00050021
,, 9, afternoon	·00050018
	·175
Mean	·00050017

that maximum divergence from the mean is ·00000004 in about 1 part in 12,000.

Mr. Crompton has been recently issuing standards of low resistance made of manganin sheet, and he was kind enough, at my suggestion, to send me one for measurement towards the end of July. It was prepared in his laboratory as a derivation from the International ohm by means of his potentimeter. Its value so given was ·00050175 at 23deg. C. Its temperature coefficient appears from Mr. Crompton's measurements to be so small that we need hardly consider it for our present purpose. My measurement of this standard was as follows:

July 29, morning	·00050219
Aug. 1, morning	·00050225
,, 1, afternoon	·00050219
,, 2, morning	·00050226
Mean	4189
	·0005[illegible]
Mr. Crompton's value	[illegible]
Difference	

is about 1 part in 1,000

Mr. Crompton's resistance is a rectangular sheet of manganin, and the potential terminals are two screws inserted at a suitable distance apart in the medium line.

Current Terminals.

The screws are not soldered. I thought it would be of interest to measure them; then screw them up again and remeasure the resistance. The results were:

Aug. 10, morning	·00050328
,, afternoon	·00050322
	·00050327
Mean	·00050326

a variation of about 1 part in 500.

I measured them again, and after screwing them once more remeasured with the following results:

Aug. 11, morning	·00050398
,, 12 ,,	·00050403
Mean	·00050401

which, compared with the first value ·0005022, gives a variation of, roughly, 1 part in 300.

The conclusion is that if Mr. Crompton desires an accuracy of $\frac{1}{10}$ per cent., which he is apparently able to obtain by his potentiometer method, he must not leave his potential terminals of his resistance loose. They must be soldered into his plate.

In making these measurements my direct object has been to obtain an accurate and ready method of measuring these low resistances. But I think something more than this comes out of them. It would be possible in the light of our present experience to construct a Lorenz apparatus considerably more accurate and easier to use than one in my laboratory at Cardiff. Such an apparatus placed in the national laboratory of which we have heard a good deal at recent meetings of the British Association, might with advantage be kept in constant use, not only for the calibration of low resistances, but also as embodying in concrete form a proper ultimate standard of electrical resistance. We have not in our electrical standard legislation given full credit to the mechanical engineer for what he can do for us, and I think that a coefficient of mutual induction arranged as in the Lorenz method, so as to be easily combined with a time, would afford a more satisfactory ultimate standard of resistance than any wire coil or coils, and one easier to use for purposes of ultimate reference than any mercury columns.

ELECTRIC LIGHT—THERMAL STORAGE—UTILISATION OF TOWN'S REFUSE.*

BY CLAUDE CHAS. KEEP.

The increasing demand for electric light has been the means of bringing the question of the profitable disposal of refuse more prominently before the public during the last two years than at any previous time. Not a week passes without one or more of the technical journals containing articles on the subject of the title chosen for this paper. Reports on electric lighting schemes by the most eminent of our engineers usually refer to it: a few say it is possible, some that it is merely probable, others again that it is impossible, to combine the two. I hope to show that it is not only possible but practicable and economical to light cities and towns, in whole or in part, by burning the refuse accumulations. But without Mr. Halpin's system of thermal storage nothing of any magnitude can be done, as the disposal of the refuse must naturally proceed uniformly, and the demand for the electric light obviously varies during each moment of the 24 hours. Thermal storage may be described as the bank: it receives the continuous but irregular earnings of the destructor, and by its well-regulated system is able to pay on demand all it has received to its regular customers, meeting their varying requirements, only charging a small percentage for the accommodation it has provided.

I purpose first to deal with the refuse question, the disposal of which must be considered primarily from the standpoint of public health, and, secondly, from that of finance; and in order to help us to come to a conclusion it will be as well to say what town's refuse consists of: Dust, ashes, wood, straw, paper, baskets, bricks, bottles, tin cans, old boots and shoes, brushes, oyster shells, old clothes, scraps of oilcloth and carpets, decaying food, dead dogs and cats, cinders, garbage, etc., collected from the markets (sometimes dry, frequently very wet); animals slaughtered when suffering from disease have also to be disposed of.

Means of Disposal.—By depositing in tips—such as disused sand and gravel pits, quarries—and filling-up low-lying ground. *By storing* in a field, with a view to selling a portion during manurial season of the year. *By sorting* and sifting out the breeze cinders and fine ash (this operation is usually performed by women). I think neither of these methods of disposal can be said to comply with the requirements of public health, and in order to show that it is a failure financially, we have only to turn to the reports of the sanitary authorities. One I have in mind received £7,000 annually; it now has to pay double this amount to dispose of it in various "tips."

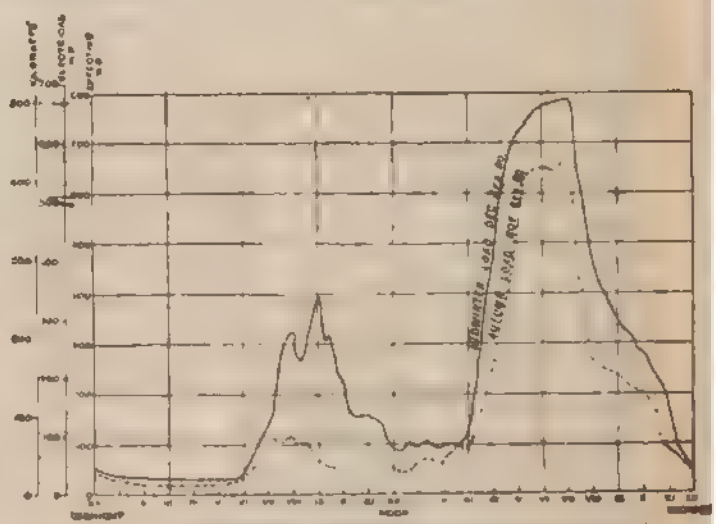
Destruction by fire completely complies with the requirements of public health, and destructors, if properly constructed and managed with ordinary care, can be erected in or quite close to cities and town without causing the least complaint, and can be made a success financially. The late Mr. Alfred Fryer invented the furnace known as "the destructor." He not only designed and patented this furnace, but coined the word "destructor," and registered it as a trade-mark. His furnaces have been erected in between 40 to 50 different towns, and have successfully dealt with all descriptions of refuse, the midden contents—sewage sludge from precipitation tanks mixed with refuse, and with dust-bin contents, which is the easiest of all refuse to burn. I am aware other furnaces have been erected in a few towns, and unfortunately have been called by the same name. The essence of Mr. Fryer's patent is the sloping hearth and grate, and the arrangement for feeding or charging the furnaces at the back, and the clinkering or cleaning of the fires at the front. In this, everyone who attempts to erect furnaces for this purpose, and who have met with any degree of success, have copied Mr. Fryer's idea, only varying in some slight details. Reports have lately appeared in praise of some of these alterations, but older students of the subject will remember, 10 to 14 years ago, most of these arrangements were tried and abandoned—for one reason, they failed in their action owing to the character of the refuse at that time: it was collected at periods varying from once a month to once in 12 months, from deep middens, generally saturated with slops, urine, excreta, etc. The water-carriage system has disposed of this difficulty, but has left with us yet another—viz., the enormous cost for repairs of the furnaces. Those features of the furnaces most discussed at the present time are automatic feeding of the fires and forced draught. Automatic feeding will not be a success so long as refuse consists of the variety of material I have mentioned. It may be stated that one fire will need to be cleaned of the clinker, etc., and recharged in less than 20 minutes, while the next charge will take from one to two hours to burn off. Automatic feeding of the fires may be more or less successful if the refuse is sorted and screened, and only the cinders are burnt, but the cost of this screening operation makes it prohibitive (Sir Spencer Wells says the system is born of a spurious economy at the cost of human life), and the material most difficult to deal with is still left to be disposed of. It is perhaps not too much to say that more complaints are made about automatic stokers working ordinary furnaces than about any other class of machinery in this country, and these, it must be noted, used screened and carefully selected coal. I believe the nearest approach to this object is to be found in Brodie and Boulnois's patent charging apparatus. I shall describe it in the words of the city engineer of Liverpool. The apparatus consists of a wrought-iron truck 5ft. in width by 3ft. in depth, and of such length as will cause it to be of sufficient capacity to hold not less than 12 hours' supply for the two cells which it commands. This truck moves along a pair of rails laid across the top of the destructor, and is capable of being worked by one man. The truck is divided into compartments holding a charge in each,

* Paper read before the British Association.

and provided with a pair of doors at the bottom opening downwards, which are supported by a series of small wheels running on a central rail. A special feeding opening in the reverberatory arch of the cell of the full width of the truck (5ft.), and placed immediately over the drying hearth, is constructed of a firebrick arch fitted into a frame capable of being moved backwards and forwards by means of a lever arrangement. The truck when empty is brought under the tipping platform, and the carts tip their contents directly into it; and when it is required to feed one of the cells, the truck is moved along so that one of the divisions is immediately above the feeding opening, and the wheel holding up the bottom doors rests upon the central rail, which is continued over the movable covering arch. Then the movable arch, actuated by the lever, is rolled back, releasing the doors and discharging the contents into the cell, so that no handling of the refuse is required from tipping to feeding. This arrangement provides portable storage for a large quantity of material, and entirely does away with the necessity for the shovelling and handling.

Forced Draught.—I find this was claimed in the original patent of Mr. Fryer. It has been applied in several places where the chimney has not been of the right design, and it has answered fairly well. At Birmingham, steam-jets have been in use several years, and extended tests have been made both with jets and fan blasts. The manager has come to the conclusion the best results are obtained by the latter. At Bradford, steam-jets blowing into large pipes have been tried, and have lately been abandoned on several of the furnaces, and jets more after the design of those in use at Huddersfield have been substituted; while at Battersea the jets first used at Bradford were tried and failed to give as good results as natural draught. Another point much debated arises over the adoption of Jones's fume cremator. Grossly exaggerated statements have been made as to the cost of working this adjunct to the destructor. Without entering into this question at the present time, and as in the future boilers will almost invariably be placed in destructor flues, objections arising from cost of working fall entirely to the ground, owing to the fact that the heat generated by its use can be satisfactorily employed.

Time will not permit me to go further into the detail of the construction of the furnaces, so I will now proceed to give you an idea as to the calorific value of the refuse. Most extravagant statements have been made about this. I have only to refer you to what I previously said refuse is composed of, and to remind you no two cartloads contain exactly the same proportions. Statements have appeared professing to give the exact composition of London dust. If these statements were the result of a whole year's collection, one might look to them for guidance. It has also been stated in the public press that the calorific value of average refuse is equivalent to 4lb. of water evaporated per hour per 1lb. of combustible matter in the refuse from and at 212deg. F., and it has also been stated elsewhere the same quantity of refuse will evaporate 0·01116lb. of water from and at 212deg. F. The one amount exceeding the other 400 times! This great discrepancy is due to the total absence of any reliable and scientific information obtained by prolonged and accurate experiments. The better result referred to was, I believe, obtained by burning a few tons of refuse under exceptionally favourable conditions totally inapplicable to general use. There appears some reason for believing the lower figure is due to very inaccurate measurements. The collection of refuse is so arranged that the destructor receives the refuse of one particular portion of its district on one particular day of the week. Each portion of a district will probably give a distinctly different quality of refuse to that of its neighbouring portion, consequently the calorific value of the refuse collected on a Tuesday will vary from that collected on Wednesday, but the total heat generated by the destructor during one week will be very nearly equal to that generated in the following or preceding week. Hence, if the dust is collected weekly from dust bins, the week is the time in which the complete cycle of changes in temperature takes place in the destructor fires. The results that can be taken from one week's working are comparable to a single steam-engine indicator diagram. We all know the danger of deducing much from a single indicator diagram. Careful observers are not satisfied unless they take a number of such diagrams and deduce their results from the mean, because, under ordinary working conditions, the load varies throughout the day. Now, under normal conditions the work of the destructor varies from summer to winter, consequently, to obtain really reliable average data, the result of one complete year's working must be acquired. Fortunately, the dust production and the electric light requirements vary in somewhat similar proportions during the summer and winter. The data of trials of the most recent type of destructors have not yet been completed, and, therefore, under the circumstances I may, perhaps, be excused for referring to trials of older destructors which have not been made generally public. At Birmingham the average evaporative power of 1lb. of refuse has been found to be equal to the evaporation of 1·79lb. water per hour. The refuse was burnt in furnaces of different types, and this result is the average of the whole burning during several years. At Warrington a different class of refuse has to be destroyed, where the evaporative power was found to be 1·47lb. water per 1lb. of refuse. I mention these two cases to indicate how great may be the difference in the calorific value of refuse collected in different towns, and it tends to prove that each town must be considered on its own merits.



LOAD CURVES KENSINGTON COURT ELECTRIC STATION

Diagram No. 1.

I should like to draw attention to the preference some engineers at the present time are giving to complicated mechanical arrangements in the furnaces. I cannot emphasise too strongly that the design of furnaces for burning refuse should be of the utmost simplicity and durability. The stoppage of a town destructor on account of repairs or some trifling breakdown in the machinery, even for a few hours, completely disorganises the whole sanitary arrangements of a town, and when in addition to this drawback the power which would have been generated to produce electric light falls short, a whole district might be thrown into confusion. Destructors can and have been erected in such a way that they have never ceased work for seven years, day and night. It may therefore be concluded that such destructor would at all events not require greater stoppage than ordinary boilers in use in central electric lighting stations.

In concluding this portion of my paper, I wish it to be distinctly understood that destructors must work continuously day and night, and as, apart from the quality of the refuse, the heat production of the destructor is nearly uniform, but is not in the most utilisable form for the generation of steam for motive power to provide electricity, hence, owing to the irregular demand for the light, the necessity for the application of Mr. Druitt Halpi[illegible] thermal storage.

It has been attempted in som[illegible] the inconvenience arising fro[illegible]

tricity by using accumulators. Their heavy prime cost, great space occupied, their costly and rapid depreciation, their efficiency of only 80 per cent., form objectionable features that militate heavily against their general adoption. I must ask you to look for a moment at the lighting curve for electric lighting. The same applies to gas—if gasometers did not exist, the gas industry would be impossible, owing to its want of financial success due to the enormous number of retorts that would have to be used to provide for the maximum load, and to the fact that these retorts must be stopped and started exactly as the demand varies, thus causing them to be subjected to excessive wear and tear owing to the sudden heating and cooling, in addition to great fuel losses, and the labour of stoking being performed in a most uneconomical way. Before proceeding to further explain Mr. Druitt Halpin's system, I wish to call your attention to diagram No. 1; this represents the lighting curve for Kensington Court station. It is taken from Mr. Crompton's paper read before the Institution of Civil Engineers, and is an average curve for a mid-winter day. Engineers prefer to provide boiler power sufficient to meet the maximum demand. The extremely short period of this duty necessitates the laying by of the greater portion of the boiler plant for frequently two-thirds or even more of the 24 hours. Not only is this an objectionable practice on financial grounds, but the constant banking-up and relighting of boiler fires involves a heavy thermal loss, the magnitude of which has probably never been accurately estimated, in addition to great loss in efficiently utilising the labour of the stokers; moreover, the quality of the water supply must influence the life of the boiler, which, in an extensive boiler plant, will probably be found to affect dividends to an extent not yet contemplated. The conditions of a good electric lighting central-station plant, therefore, involve the reduction of the boiler power to a minimum, and the omission of the present expensive accumulator system, combined with an ample supply of suitable boiler feed-water. After studying for a considerable period the principles underlying Mr. Druitt Halpin's thermal storage system, of which so much has been said and written during the past year, I have come to the conclusion that these difficulties can be overcome by its adoption. By a fortunate combination of circumstances it is also peculiarly adapted to use with the destructor.

The system of thermal storage contemplates the working of a sufficient number of boilers during the whole 24 hours to produce the mean desired amount of steam and deliver the steam given off into reservoirs of suitable strength and capacity, containing sufficient water to store up part of the heat in the steam when the engines are working at a light load or when stopped to store up all the heat the boilers can produce. The boilers are preferably worked at a higher pressure than the engines, and the difference of pressure between the engines and the boilers is necessarily accompanied by a difference of temperature, and having a large mass of water available at this higher temperature really constitutes the source of the stored energy, thus justifying the application of the title of thermal storage to the system. It is well known that the majority of boilers are fed with more or less impure water, but in the thermal storage system the impurities are deposited in a place where they can do no harm, and the boilers are fed with clean water, thus avoiding incrustation, which entails expensive and imperfect cleaning, thus obviating the loss of fuel due to deposit, and reducing materially the wear and tear of the boilers.

Mr. Halpin's system may be carried out in whole or in part. *The first scheme (called steam storage)* contemplates the heating of such a volume of water during slack times by the excess steam, that this water will be able to provide the necessary excess of steam for the engines during heavy load, and thus to evaporate such portions of this water as the boilers are not able to cope with. It will be found that in this system the whole of the excess steam generated during the light load of 16½ hours can be utilised in heating the water and given back again in sufficient quantity during heavy load to enable the boilers to be worked uniformly throughout. A feature of this scheme is that a uniform continuous feed is contemplated. (It may be called *complete steam thermal storage*.)

The second scheme (called feed storage) is a means of providing the boilers with clean feed-water at the temperature of the steam in the boilers. The whole of the feed-water needed for evaporation during the 24 hours is pumped into storage tanks, and during the light-load period of, say, 16½ hours it is raised to the temperature of evaporation by the excess steam generated during this light-load period. During heavy load the boiler can be supplied with feed-water at the temperature of the steam, but the fires have still to supply the heat necessary to produce evaporation—that is, to add the latent heat to the steam.

The third scheme (called combined feed and steam storage) is simply a combination of the first and second schemes, and differs only in the period of delivery and temperature of boiler feed-water. In this case, the whole of the feed-water is delivered into thermal storage reservoirs and heated during slack load to the required temperature of evaporation. This also is a complete thermal storage system.

As all these schemes must be reduced to figures to enable you to judge of their practicability, I will now take an instance of a district of the city of Edinburgh for which I have been enabled to obtain sufficient data. I am informed that the lighting curve before referred to may be assumed to represent that for this district without great inaccuracy.

Assume that feed storage tanks only be provided sufficient to hold the whole of the water required by the engines during the 7·1 hours' heavy load, and that this volume is heated from 100deg. F. to 347deg. F. = 115lb., the pressure at which the engines are working during slack load. Without wearying you with all calculations (which I have given in detail in the appendix), it may be seen that with hot feed the boiler power can be reduced 22 per cent., and that this reduced boiler power will only have to work 4¾ hours at full power, or the equivalent thereof, out of the 16·9 hours of light load. Owing to the reduction in boiler power, the total prime cost of the plant with feed storage tanks is almost exactly the same as if boilers had been provided to do the whole work, and in addition to this the necessity for extra chimney that would be required by those boilers detached from the destructors entirely disappears. Working expenses of the plant with storage tanks should be considerably less, owing to the more regular duty which is imposed upon the boilers, and to the fact that incrustations will be absent in the boilers. As all the necessary heat is obtained from the refuse burned in the destructors, the whole of the fuel and labour of stoking otherwise required is obviously saved.

Secondly. Assume the plant fitted up with thermal storage tanks and feed storage tanks on the lines of the third scheme. The boilers in this case are supposed to work at 250lb. pressure and capable of meeting the average load during the 24 hours, but experience has shown that the high pressure will not cause any difficulty either in the boilers or in the thermal storage reservoirs. You are no doubt aware that tanks, 8ft. diameter × 30ft. long, working at 250lb. pressure, have been in use for some time for creosoting purposes. It is assumed the engines work, as before, at 115lb. pressure, and from the figures in the appendix it may be seen that the boiler power need only be one-third of that required if no thermal storage reservoirs were provided. Referring again to the figures in the appendix, it will be seen that even with an evaporative power of 1lb. water to 1lb. refuse, and allowing 40lb. water per kilowatt, that ample heat can be generated by the destructors by the burning of 80 tons per diem to supply the whole of the steam for such a central station.

I have shown that at Warrington the average evaporative power of the refuse throughout the year is 1·47lb. of water per pound of refuse. My experience in this matter teaches me that it is unlikely the summer's evaporative power will be less than 1lb. per 1lb. of refuse; the equivalent figure during the winter months will probably approach 2lb. water per 1lb. refuse, and hence you will notice I have based my calculations of the evaporative power on the assumption that summer refuse is supplied to the destructor throughout the year, but that the electric light is produced according to winter requirements. I may observe that at Liverpool the duty produced by the boilers in the winter is four times as great as that obtained in summer.

In concluding this paper, I may be allowed to express the hope that your patience has not been overtaxed. It will readily be admitted that the importance of the subject can scarcely be overestimated. The various opinions held by engineers are doubtless represented amongst my hearers, and though I can hardly hope to have succeeded in convincing all as to the position I have taken up, I do trust that in this direction something has been done. The subject I hope will be favoured with the best consideration and the most incisive criticism of all the sections, as it is only in this way the truth can be arrived at and thoroughly established.

APPENDIX.

The day of 24 hours may be divided into two periods—*i.e.*, period of slack load; period of heavy load. Period of slack load amount to 16·9 hours; period of heavy load amount to 7·1 (3.15 p.m. to about 10.20 p.m.). It is true that from 7.20 a.m. to about 9.40 a.m. the mean load is slightly exceeded, but of course, so far as storage tanks are concerned, they must be provided for the *greatest excess load* only.

Second Scheme (Feed Storage).—Let the storage tanks be sufficient to hold whole of water necessary for engines during 7·1 hours heavy load, and that this volume be heated from 100deg. F. to 347deg. F. during slack load. The boilers and engines work at 115lb. Now the maximum rate at which the power is required is 597·7 kilowatts, or about 800 e.h.p. The mean load on engines = 187·5 kilowatts, and for the given working conditions it may fairly be assumed that not more than 40lb. of water per hour per kilowatt will be consumed. Hence the average water consumption per hour should be 7,500lb. Total water used during 24 hours, 180,000lb.

Note.—Without storage tanks the maximum steam to be supplied by boilers (597·7 × 40lb. per hour = 23,908lb. per hour from 100deg. F. at 347deg. F.

Maximum heat required = 23,908 (1,220 − 100) thermal units per hour = 26,778,000 thermal units.

Now with storage tanks delivering feed at 347deg. F.

Maximum heat required = 23,908 (1,220 − 347) thermal units per hour = 20,873,000 thermal units.

Hence if feed can be supplied at 347deg. F., the boiler powers can be reduced in ratio $\frac{20,873,000}{26,778,000} = 0·7795$ or by 22 per cent.

Next, given storage tanks for heavy load, can 180,000lb. be heated from 100deg. F. to 347deg. F. during 16·9 hours slack load? By hypothesis the total boiler power is capable of furnishing 20,873,000 thermal units per hour.

During light load, 16·9 hours, the boilers have:

(1) To provide latent heat for engine steam.

(2) To raise 180,000lb. water from 100deg. F. to 347deg. F.

Area under curve during the light load = 0·973 square inch, length of base = 2·64in., therefore mean heat = $\frac{0·973}{2·64}$ = 0·3686in.

The scales are 1in. = 6·3995 hours, and 1in. = 247 kilowatts, or 9,880lb. water per hour.

Hence mean boiler duty during 16·9 hours = 0·3686 × 9,880lb. water per hour = 3,642lb. per hour, and total water during light load = 3,642 × 16·9 = 61,550lb.

	Thermal units.
Latent heat of evaporation of 61,550lb. at 347deg. F. = 61,550 × 873 thermal units ...	= 53,730,000
Raising 180,000lb. 247deg. F. = 180,000 × 247deg. F. thermal units	= 44,464,000
Total boiler duty during 16·9 hours' light load in thermal units	98,194,000

The boilers are capable of giving 20,873,000 thermal units per hour; hence, they will have to work $\frac{98,194,000}{20,873,000}$ hours = 4·70 hours at full power (or the equivalent thereof) during the 16·9 hours' light load.

Total Tank Capacity.—Water to be stored = water of evaporation during 7·1 hours' heavy load.

Area enclosed between curve and base line during this 7·1 hours = 1·827in.

$$\text{Mean heat} = \frac{\text{area}}{\text{base}} = \frac{1·827}{1·11} = 1·6459\text{in.}$$

1·6459 = (1·6459 × 9,880) lb. water per hour = 16,262lb. per hour.

Total water = (16,262 × 7·1) lb. = 115,465lb.

Assume net capacity of one tank = 75,000lb., then number of tanks = $\frac{115,465}{75,000}$ = 1·54 tanks.

Allow 12 per cent. for water expansion 0·2 tank.

Total tanks required = 1·54 tanks, say 1·75 tanks.

Relative Cost of Boiler Scheme With and Without Storage.—Without storage, boilers must be capable of evaporating from 100deg. F. at 347deg. F. 23,908lb. per hour, and must be capable of yielding about 800 e.h.p. Assuming cost of water-tube boilers to be £3 per electrical horse-power, then cost of boilers = £2,400.

We have seen that with storage the boilers may be reduced 22 per cent., hence cost is then	£1,872
Allowing £500 for each tank, 500 × 175	875
Total cost	£2,747

For a small scheme such as this, the difference in first cost is not great, and in large schemes difference is in favour of thermal storage system.

Third System (Complete Thermal Storage and Feed Storage). Boilers work at 250lb., and are sufficient for average load only. Whole feed is supplied during light load, and the storage water at 406deg. F. is sufficient to contain heat for latent heat of evaporation for excess steam during heavy load.

Available range of temperature, 59deg. F.

Engines work at 115lb., or 347deg. F.

Boiler duty during light load comprises:

1. Heating of 180,000lb. water from 100deg. F. to 347deg. F. (feed). 2. Heating storage-tank water from 347deg. F., to 406deg. F. 3. Evaporating 44,349lb. water at 347deg. F., being water required during light load for engines.

The excess steam to be evaporated by storage-tank water is shown on diagram enclosed between red curve and mean height line.

This area in all = 0·66 square inch = 41,735lb. water to be evaporated at 347deg. F.

Total heat required = 41,735 × 873 thermal units.

Storage water in tanks = 41,735 × 873lb. = 617,500lb.

(Storage water only falls 59deg. F. in temperature.)

Number of tanks required for steam water storage

$$= \frac{617,500}{75,000} = 8·23.$$

Allowing 12 per cent. for water expansion, about nine tanks are required. For feed-water storage we have seen about 1·75 tanks are required.

About 11 tanks in all are necessary.

Returning to boiler duty during light load—

				Thermal units.
(1)	180,000 × 247	thermal units	=	44,462,000
(2)	617,500 × 59	" "	=	36,438,000
(3)	44,349 × 873	" "	=	38,712,000
				119,612,000

Average boiler duty = 8,981,000 thermal units per hour.

$$\frac{119,612,000}{8,981,000} = 13·32 \text{ hours.}$$

9·395 (heavy load period).

22·715 hours.

During the 24 hours the boilers work at full power for 22·7 hours.

In this scheme the boilers are proportioned to give 187·5 kilowatts, or about 250 e.h.p.

Costs of this Scheme.

Eleven storage tanks at £600 each, to stand 250lb. per square inch, and to contain 75,000lb. water...	£6,600
Boilers to give 250 e.h.p. at £3 per e.h.p. plus 5 per cent. for extra pressure	850
	£7,450

THE

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WERNER VON SIEMENS.

There are some names that live in history, there are others which abound for a season and are soon forgotten. The name of Siemens is one that will last, because it belongs to those who have made history rather than to those who loom largely before their generation as expounders without orignation. It is not our intention to dwell lengthily upon the personal characteristics, or even the personal work, of this scion of a celebrated family—a full account of these will be found in the personal recollections just published in book form by Messrs. Asher and Co. If we attempt to consider, not the position of one brother but the work the house of Siemens has done in the development of electrical engineering, we must acknowledge that it has ever been in the forefront; that by its brain power, coupled with its excellent mechanical exposition of that brain power, it has done more than any other house or firm to make the world acknowledge the possibilities of electricity. Almost the first paragraph of the book above referred to shows the characteristic moving spirit of the Siemens brothers. Whether physically, mentally, or commercially, troubles loomed ahead, they met them, and energetically repelled them. Werner met with success in driving away a troublesome gander, because he reasoned that his father's experience was right, though his own fears might lead to an opposite conclusion. The young warrior scored a victory which stood him in good stead in after years. When reason and experience said a thing could be done, whenever they pointed to a probability of its being done, no stone was left unturned to succeed. Brother assisted brother, and with the aid of Halske, whose name is inseparably connected with that of Siemens, the success has been great. Telegraphy in the public mind has given place to electric lighting and transmission of power. Familiarity with it has led to a depreciated idea of its effect upon the history of the world, but to those who can recollect the methods of communication before the end of the thirties, and compare the then methods with those now so common, the difference is startling. In every branch of telegraphy the house of Siemens has taken a prominent position; but let us consider for a moment what it has done for electric lighting and transmission of power. We have the names of Pacinotti and Gramme continuously before us, although a closer attention to history would show that Siemens could claim as prominent a position in the development of the dynamo. The recollections contain references to the controversy as to the application of guttapercha for insulating purposes, and a history of telegraphic progress both on land and on the ocean bed. It is, however, to the history of the dynamo that attention is here directed. On page 330 the recollections say: "This was the discovery and first application of the dynamo-electric principle underlying all dynamo-electric machines." The paper embodying the descriptive details of this discovery was, if we recollect aright, read at the Royal Society in conjunction with one of Prof. Wheatstone's, in which a similar discovery was described. These two Royal Society papers are

always quoted as showing how discoveries in the same direction can be made independently by workers far apart. The claim of Werner Siemens to priority is shown and has generally been admitted. How rapid the development has been during the quarter of a century succeeding this discovery is known to us all; and again the house of Siemens has been the foremost of the workers. It is good that such recollections are published. It is good in times when the principles involved and the apparatus employed are common knowledge to now and again consider the step which led to the known from the unknown—a step seemingly small and plain, but one which was long a-coming, yet when taken changed the course of civilisation. To the Siemens brothers belong all honour and credit for this and other discoveries; hence a book of recollections plainly setting forth the working of the mind of one of these eminent men is of value to all engaged in like work. Mankind, in the stress of living, is too apt to run to extremes of praise and blame, but the earnest workers in electrical matters will agree that in this direction the meed of praise to the Siemens family can hardly be made too great.

ELECTRICAL PAPERS READ BEFORE SECTION A OF THE BRITISH ASSOCIATION, 1893.

BY JAMES L. HOWARD, D.SC.

Since the Mechanical Science Section of the British Association (Section G) began to devote one of its sittings to the discussion of papers on subjects connected with electrical engineering, the electrical papers of the Physical Section have become annually less and less technical in character. This tendency has been shown very clearly at the recent meeting, where a large percentage of the electrical papers referred to that portion of the science which the uninitiated commonly, but somewhat vaguely and erroneously, call "Maxwell." But in spite of this several results of interest to electricians were made known, which it will be best to describe in order.

The Committee on Solar Radiation have in past years measured the intensity of the sun's heat by the rise of temperature of a mercury thermometer whose green glass bulb was exposed to it. Such a thermometer was sluggish in action, and during the year it has been replaced by a thermo-electric junction consisting of a blackened copper disc with an attached iron wire. The new apparatus is very sensitive, five seconds' exposure to sunshine causing it to register, and with a photographic recording apparatus it promises to be an efficient quantitative sunshine-recorder.

The Committee for Comparing and Reducing Magnetic Observations report that they have recommended the Admiralty to establish a magnetic observatory at the Cape of Good Hope. Another committee presented an account of magnetic work done at Falmouth Observatory, of a character similar to that of Kew.

Prof. G. F. Fitzgerald introduced a subject which has hitherto been very slightly discussed—namely, the magnetic effects of electric charges moving over the earth's surface. Suppose equal and opposite electric charges originally concentrated at the poles to unite. Electric oscillations would be set up on the earth's surface whose period has been calculated by Prof. J. J. Thomson and Mr. Heaviside to be about one-seventeenth of a second. A suspended magnet with this period of swing would be disturbed by them. A similar disturbance on the sun's surface would have a period of 6½ seconds. Prof. Oliver Lodge has tried to detect the latter effect, but without success. Prof. Fitzgerald indicated another mode of oscillation, regarding the earth as a condenser with the surfaces of the upper atmosphere and of the crust as its coatings. The discharge of such a condenser would give rise to disturbances of one-tenth to one second period, depending on the thickness assumed for the non-conducting portion of the atmosphere. It was suggested that these disturbances be sought for by suspended small magnets having their periods of swing within these limits.

A very valuable set of tables showing the electro-chemical properties of various salts in aqueous solutions of different strengths was presented, having been drawn up by the Rev. T. C. Fitzpatrick. The tables include (1) specific gravity data—viz., percentage composition, molecular composition, specific gravity, and temperature; (2) electrical conductivity with its temperature coefficient, and specific molecular conductivity; (3) a table of migration data for each salt; (4) fluidity data, the reciprocal of the viscosity or fluid friction. These tables will be useful in estimating the resistance of liquids for practical purposes, as well as for theoretical investigations.

Prof. Oliver Lodge has been endeavouring to ascertain throughout the past two years whether a mechanical connection exists between ether and matter. This problem is of extreme importance in determining the exact nature of electrical actions, but its solution presents very great difficulties. Dr. Lodge has attacked it by examining whether the ether near a rapidly spinning body is set in motion or not. If it is, a beam of light travelling in the same direction as the body will be accelerated, while a similar beam travelling in the opposite direction will be retarded. In the experiment these two beams set out from the same source, travel in opposite directions along nearly the same path, and are then examined together by a telescope; any changes in their velocity would be indicated by a shift of the interference bands produced by them. The rotating body consisted of two parallel steel discs about a yard in diameter, mounted on the same vertical axis about an inch apart, and driven by an electric motor at about 3,000 revolutions per minute. After eliminating all disturbing causes, it was found that no effect was really produced on the beams, from which it is concluded that moving matter does not move the ether in its neighbourhood by any direct mechanical process. Dr. Lodge is of opinion that the interaction of ether and matter is always accompanied by electric or electro-magnetic stresses, and he thinks it just possible that the ether in a space between two oppositely charged discs would be moved along with the discs; although it does not move when they are not electrified. The result of this experiment will be watched with interest.

The subject of piezo-electricity, the development of electric polarity on compressing or distending a plate of crystal, has been occupying the attention of Lord Kelvin, who communicated a paper on the theory of it. He supposed it to be due to alteration in the mutual distances of oppositely charged atoms in neighbouring molecules; this is equivalent to altering the distance apart of the coatings of a charged condenser, which would change their potential difference. Lord Kelvin illustrated his theory by a "piezo-electric pile," a description of which was given in last week's number of this journal (page 277). Starting from the theory given by Lord Kelvin, the amount of the charge on each atom has been calculated by Prof. Chattock (*Phil. Mag.*, December, 1892), who finds it to agree with the value derived from electrolytic data.

Two papers on electric waves give accounts of experiments made under the direction of Prof. Hertz at Bonn. That of Mr. E. H. Barton depends on the fact, discovered by Herr von Geitler, that an electric wave travelling in the space between two parallel wires is partially reflected at places where the wires change in capacity, conductance, or distance apart. Let a length of thicker or thinner wire be placed in each of two similar long parallel wires. Waves set up at one end in the ordinary way (by means of a Hertz oscillator and secondary conductor) would reach the portion of different thickness. A part would be reflected and the rest transmitted. The latter would again suffer partial reflection on reaching the point where the conductor regained its original thickness. The interference of these reflected waves gives

rise to nodes and ventral segments, the positions of which have been traced by Mr. Barton, who aptly compares them to the phenomenon of Newton's rings in optics. The other paper, by Mr G. U. Yule, has for its object to determine the thickness of electrolyte necessary in order to completely absorb an electric wave passing between two parallel wires. The wires were arranged as in Mr. Barton's experiment, but were of the same thickness throughout. They were caused to pass down the whole length and through the bottom of a jar containing the electrolyte, and the smallest depth of electrolyte was noted which would suffice to absorb the waves passing into it. In this way Mr. Yule has shown that the electric resistances of electrolytes bear almost the same proportion to each other when measured for waves whose rate of alternation is a million per second, as they do for steady currents. He also established the high resistance of water for such rates of alternation. It will be remembered that Prof. J. J. Thomson obtained similar results some time ago, allowing the radiation from an oscillator to fall on and be absorbed by a layer of electrolyte. The present experiments differ from those of Prof. Thomson in that the waves are prevented from spreading in all directions, being constrained to move between the parallel wires.

To the electrical engineer one of the most important papers of the meeting was that of Prof. Rucker on the "Magnetic Shielding of Two Concentric Spherical Shells." The question of shielding electric railways so that their magnetic effects shall not disturb electrical instruments in their neighbourhood has attained to some degree of importance since objections were made to the passage of an electric railway near the Colleges in Exhibition-road, on the ground that it would disturb the instruments of their physical laboratories. Magnets moving on the cars would also disturb any telegraphic or telephonic systems in their neighbourhood unless the magnets are surrounded by some sort of screen. Prof. Rucker has obtained by a spherical harmonic analysis the magnetic force outside two concentric spherical shells due to any distribution of magnetism inside. The general equations are long and somewhat complicated, but special interest attaches to the case of a magnet at the centre of the shells. Regarding the shells as equivalent to a spherical shell of high permeability, with a "spherical" crack inside it, the screening effect is a maximum for a given mass of shell when the volume of the crack is the harmonic mean of the inside and outside volumes of the shell. This result will enable us to surround dynamos and motors with a far more efficient sheath than before. Prof. Fitzgerald was not so successful in an attempt to calculate the screening effect of a long cylinder, but had to be content with laying the equations for this case before the section. The papers of Prof. Fitzgerald, on "The Effect of a Hertzian Oscillation on Points in its Neighbourhood," and of Dr. Larmor, on "Magnetic Action on Light," were also of a mathematical character. In the latter attention was called to a difference in the views of Berlin and Gottingen physicists respecting the reflection of light from a magnet, and electromagnetic equations generally; and Dr. Larmor showed how the equations might be simplified so as to include only two terms, of which one corresponds to the Hall effect and the other to the rotation of plane of polarisation of light reflected from a magnet. Dr. Larmor's paper was regarded as of peculiar interest and importance by the mathematical physicists present, and was subsequently ordered to be printed *in extenso*.

In their report on the application of photography to meteorology, the committee have advanced a new theory respecting the ribbon structure shown by photographs of lightning discharges. They consider that a discharge may consist of several flashes in rapid succession along almost identical paths. If the air were still, the path marked out by the first flash would be followed by subsequent ones, and the photograph would present the appearance of a very narrow band; but with moving air the path of least resistance taken by the first flash becomes appreciably shifted before the second flash takes place. This flash, therefore, appears by the side of the first, but the two are not exactly coincident, thus causing the photograph to show a broad band.

The electrical world is indebted to the Electrical Standards Committee of the British Association for having at last secured a practically universal unit of resistance. The president referred in his inaugural address, and later in the report of this committee, to the fact that the Governments of France, Italy, Austria, Germany, and the United States had adopted the unit of resistance recommended by the committee to the English Board of Trade. The unit is obtained by taking a tube 106·3 centimetres long and of such a uniform cross-section that it is just filled by 14·4521 grammes of mercury when at 0deg. C. The resistance of the tube full of mercury is one unit. The original B.A. unit is ·9866 times the new one. The committee have obtained 21 copies of the unit or its multiples during the year, which Mr. Glazebrook will from time to time compare with the standard. As yet the new unit had not till recently received any name. Four were submitted to M. Mascart—namely, "international," "normal," "etalon," and "ohm de 1893." The B.A. committee prefer the first one, but would adopt any of the first three. The name "international ohm" has been agreed to. They have not come to any decision with respect to the name "henry," which the Chicago Congress has adopted for the unit of self-induction, but are understood generally to approve. Some condensers constructed 23 years ago by Dr. Muirhead have been retested, and their capacity differs only by 1 part in 5,000 from that assigned to them at the time they were made. We may conclude, therefore, that standard condensers do not alter in value with time.

The association's standard coils do not include submultiples of an ohm, and Prof. J. Viriamu Jones has been applying the method of Lorenz to construct standards of low resistance—such as would be useful in practice for measuring large currents. Lorenz's method consists in balancing the E.M.F. between the centre and edge of a copper disc spinning in the magnetic field of a coil conveying a current, against the potential difference between the ends of a resistance traversed by the current. The only data necessary are the speed of the disc and the mutual induction between the coil and disc, the latter of which may be calculated. The moving contact at the edge of the disc was made by a perforated tube, from which mercury under pressure oozed out. The speed was regulated by a stroboscopic circle and an electrically-driven fork, as in Lord Rayleigh's experiments by the same method.

Prof. Oliver Lodge described the design of a ballistic galvanometer intended for physiological work, but applicable to all purposes for which ballistic galvanometers are usually employed. He thought that in such instruments the long period of swing should be attained without lessening the sensitiveness by having an extremely light and highly magnetised needle, and by avoiding damping. He, therefore, proposed to make the moving parts as light as possible, at the same time reducing the surface so as to diminish the damping; the coils to be fairly small and numerous (say, four pairs), and each pair having a magnet at its centre. The magnets were to be made of pieces of very thin steel wire fastened to a disc nearly fitting the coil, to be rigidly fastened together as an astatic system, and suspended by a quartz fibre. As the moving parts usually include a mirror, which adds greatly to their weight, Prof. Lodge proposed to replace this by a light pointer, such as the sting of a bee, which could be viewed by a microscope having a graduated eye-piece. He believed biologists would like this plan, but he found that instrument makers fought shy of it, and greatly preferred the mirror. The only other requisite was a very weak controlling magnet, which might consist of two magnets opposing each other. An instrument made as nearly as possible on these lines had been constructed and was exhibited by Mr. F. H. Nalder, who stated that it was fully twice as sensitive as the ordinary ballistic galvanometers of the same resistance, and that its figure of merit could be still further increased.

A new feature in connection with the section this year was the exhibition of scientific apparatus and photographs in rooms adjoining the section. The Cambridge Scientific Instrument Company sent several instruments, among which was Callendar's platinum pyrometer for measuring the

temperature of a furnace by the alteration in resistance of a platinum wire exposed to its heat. Messrs. Nalder Bros. and Co. were represented by several instruments, including Prof. Ewing's magnetic curve-tracer, and Dr. Lodge's galvanometer, described above. They also sent an apparatus for comparing nearly equal resistances by Carey-Foster's method, which has the merit of being exceedingly compact. The ratio coils are both wound on one bobbin, so as to ensure their having the same temperature; a half turn of a circular commutator interchanges the two coils to be compared, and a short bridge wire is included on the same base. To give the instrument a wider range the bridge wire can be replaced by others of different thicknesses, the resistance of unit length of each being known. Mr. R. W. Paul exhibited electric measuring instruments of the d'Arsonval type for use near dynamos. Messrs. Pyke and Harris lent a small alternator and transformer of a size suitable for laboratory experiments; and Messrs. Newton and Co. showed electric lanterns and projection apparatus. Of the photographs, some by the Rev. F. J. Smith, called by him "Inductoscripts," were of great interest. They are produced by placing a coin (or indeed anything with a pattern on it and which is capable of conducting electricity) pattern downwards on the film of a photographic plate resting on a large metallic plate. The coin and metallic plate are then connected either to an induction coil or an electrical machine, and a spark is passed between them. On developing the photographic plate an image of the coin appears on it. In this way Mr. Smith has copied coins, copper-plates for engraving, and even leaves, after making them conductors. Bromide paper may be used instead of plates with equally good results.

The industry of Section A, whose sittings are the first to commence and the last to terminate, has been frequently commented on. This year, however, there were fewer papers than usual, and a Wednesday sitting was found to be unnecessary. The papers have been well discussed, and although there was nothing of a nature to cause excitement such as that occasioned by the preparation of fluorine or the narrative of a voyage to the Antarctic regions, yet the meetings of the section were certainly free from dulness to anyone understanding the subjects discussed, and they have been well attended throughout.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE I.

(Continued from page 283.)

Indicated and Effective Horse power.—In questions of power distribution, it is clear that it is the effective horse-power delivered at the crankshaft, and not the indicated horse power developed in the cylinder, which has to be considered. It is due to the difficulty of determining in most cases the mechanical efficiency of an engine that engineers have been content to reckon on the indicated horse power. It is true that the engine friction is not a very large fraction of the power developed in full load trials, nor does this fraction vary very greatly at full load for different engines. But it is erroneous to assume tacitly that the engine friction is, in all cases, a quantity of relatively little importance, or that it is immaterial whether the indicated or the effective horse-power is used in calculations.

Influence of Mechanical Efficiency on the Economy of Working with a Varying Load. The mechanical efficiency of steam engines, or the ratio of the effective to the indicated power at full load, is 0·8 to 0·85 for small engines, and may reach at least 0·9 for large engines. It is a little greater for non condensing than for condensing engines, and for simple than for compound. A triple-expansion engine, constructed by Messrs. McLaren, tested on a brake, gave 122 i.h.p., and 107 on the brake—an efficiency of 0·88. The loss of power due to engine friction is not very great or variable so long as the engines are worked at full load. It is quite otherwise, however, at light loads, and the extent to which this affects the economy of working has been overlooked.

Many experiments show that the engine friction is nearly the same at all loads. Suppose that at full load an engine gives 100 i.h.p. and 85 e.h.p. If the friction is constant, then for smaller loads the efficiency diminishes as shown in Table IV.

The steam and coal used depend on the indicated power—the work done on the effective power. The decrease of mechanical efficiency for light loads has a serious effect on the economy of working with a varying load.

* Howard Lectures delivered before the Society of Arts.

TABLE IV.—Mechanical Efficiency of Engines with Varying Load.

Indicated h.p.	Effective h.p.	Efficiency.
100	85	·85
75	60	·80
50	35	·70
25	10	·40

Careful experiments on mechanical efficiency with varying loads are not very numerous. It is useful, therefore, to give the results of some experiments on a Corliss engine of about 180 i.h.p. at full load. This engine was tried with a brake at Creusot, both condensing and non-condensing. It was found that the results agreed approximately with the following equations:

Condensing .... $T_e = 0·902\,T_i - 16$
Non condensing .... $T_e = 0·945\,T_i - 12$

equations which give results not differing greatly from those obtained by assuming the friction constant. The following are the calculated values of the efficiency.

TABLE V.—Mechanical Efficiency of Corliss Engine with Varying Load.

Actual effective power. / Power at full load.	Mechanical efficiency. Condensing.	Mechanical efficiency. Non-condensing.
1·0	·82	·86
·75	·79	·83
50	·74	·78
·25	·63	·67
·125	·48	·62

Influence of the Loss due to Back Pressure on the Economy of Steam-engine Working.—Besides engine friction, there is another waste of energy in the steam engine which has, to an even greater extent, been overlooked. The effective power is less than the indicated power by the engine friction; but the indicated power itself is less than the work done by the steam by the amount of work done against back pressure.

In condensing engines the back pressure is comparatively small, but in non-condensing engines the back pressure exceeds 15lb. per square inch. Its influence on economy, even at full load, is considerable, and at light loads it may become excessively great.

In engines working, as most engines do, at constant speed, the work against back pressure is nearly independent of the load.

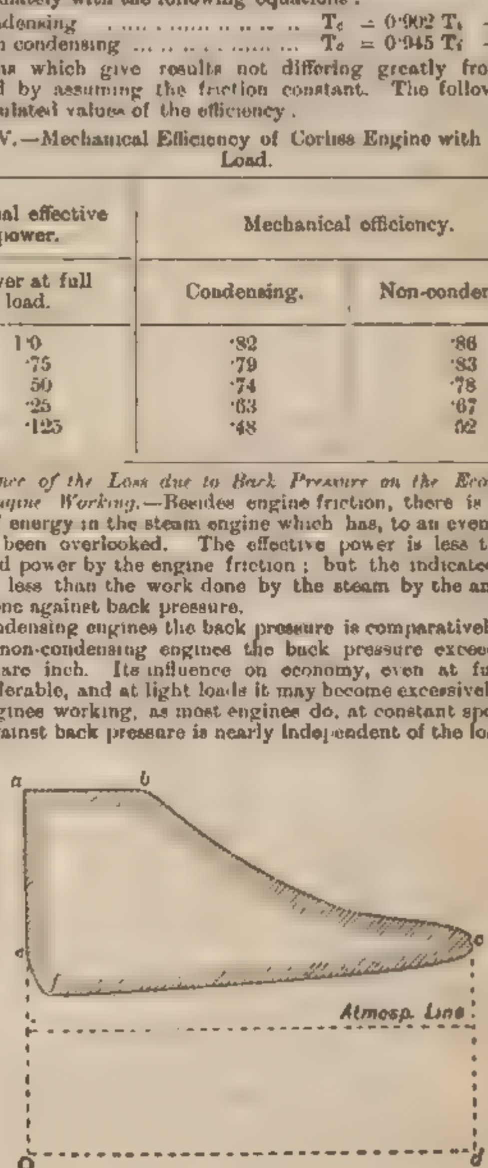


FIG. 5.

In interpreting an indicator diagram, Fig. 5, the total work done by the steam on the piston, called by some continental writers the absolute indicated work, is the area $O\,e\,a\,b\,c\,d$. The work afterwards wasted in overcoming back pressure is $O\,e\,f\,c\,d$. The difference is the effective work, $e\,a\,b\,c\,f$. The quantity of steam used depends on the absolute indicated work; the useful energy obtained on the effective indicated work. If the back pressure work is constant, it becomes a larger and larger fraction of the absolute work as the load on the engine is diminished.

Suppose, in a non condensing engine the work against back pressure is 20 per cent of the absolute indicated work of the steam at full load. Then for other loads the work is distributed thus:

TABLE VI.—Waste of Work due to Back Pressure.

Absolute indicated work of steam.	Work against back pressure.	Net or effective indicated work.
h.p.	h.p.	h.p.
125	25	100
75	25	50
50	25	25
37½	25	12½
25	25	0

Condensing Triple.

$$W = 112 + 13{\cdot}75 \text{ i.h.p.}$$
$$= 377 + 13{\cdot}75 \text{ e.h.p.}$$

If instead of calculating the total steam per hour, W, we calculate the steam per horse-power hour, we get results which, plotted like the previous diagrams, give rectangular hyperbolas, curves which agree closely with the theoretical curves for the case of varying pressure previously given. To show the great variation of steam consumption, these values are given in Tables VIII. and IX. for full load, half load, quarter load, and one-eighth load.

TABLE VIII.—Steam Consumption, Pounds per Indicated Horse-power and Pounds per Electrical Horse power Hour.

	Non-condensing.		Condensing triple.
	Compound.	Triple.	
Indicated h.p.			
100	21·5	18·2	14·9
50	26·7	22·7	16·0
25	37·2	31·7	18·2
12½	58·2	49·8	22·7
Electrical h.p.			
80	26·9	22·8	18 5
40	37·5	31·9	23·2
20	58·7	50 0	32·6
10	101·2	86·2	51·4

TABLE IX.—Steam Consumption in Engines Working with a Variable Load.

—	Average load factor.	Steam consumption in lbs. per average e.h.p. hour.	Per cent. increase of steam consumption due to variable load.
I. 500-e.h.p. engine	0·22	50	108
Ia. 500-e.h.p. engine and similar engine running at half speed	0·19	67	180
II. 200-e.h.p. engine	0·49	34·5	44
IIa. do. with one similar engine running at half speed ..	0·36	42	75
III. 100-e.h.p. engine	·65	29·5	23
IIIa. do. and one similar engine running at half speed...	·53	33·1	38

Increase of Steam Consumption Working with a Variable Load.—Captain Sankey has applied Mr. Willans's formula to find the steam consumption of one or more engines working against a variable load, as in an electric lighting station. He takes a normal mid winter load curve and examines how the necessary current could be supplied during the 24 hours (1) with one engine capable of exerting the maximum power required; (2) with smaller engines. He also considers the steam consumption when one additional engine is kept running at half speed as a stand by in case of accident. The results rearranged and a little modified are given in the preceding table. It is assumed, for convenience, that the maximum load is 500 e.h.p., and that the engines are non-condensing.

Influence of Irregular Working of the Boilers on the Expenditure of Fuel.—With a varying load the steam consumption, and consequently the fuel consumption also, is increased (1) in consequence of the decreased mechanical efficiency of the engines with light loads; (2) by the greater proportion the work expended in overcoming back pressure bears to the total work of the steam; (3) by the diminished thermal efficiency of the engine. But all these causes taken together do not explain fully the great fuel consumption in such cases as electric lighting stations. There is another very obvious cause of uneconomical working which cannot at present be estimated quantitatively for want of sufficient experimental investigation. With a very varying load, boilers must be put in steam and banked up alternatively, and the waste in getting up steam and allowing the boilers and brickwork to cool down again is no doubt considerable. This waste is at present unavoidable, except so far as means can be adopted to improve the load line.

Some tests, made by Prof. Kennedy at the Millbank street station of the Westminster Electric Supply Corporation, indicate pretty clearly a boiler waste additional to the engine waste. Dividing the day into three portions, he determined the fuel consumption, the feed water evaporated, and the indicated and electric horse power developed during each period. It will be seen that during the periods of light loading the fuel consumption per horse power hour is very large.

Perhaps the fairest way of considering the waste due to variable load will be to compare the mean consumption in the 24 hours with the consumption between 6 p.m. and midnight, when the load was heaviest. It will be seen that the mean steam consumption per electrical horse power hour was 24 per cent. greater than during the period of heavy load. But the mean consumption of coal per electrical horse power hour was 46 per cent. greater than during the period of heavy load. The difference of [illegible] per cent. must be attributed to waste at the boilers, due to irregular working. During the whole 24 hours the mean evaporation, in pounds of water per pound of coal, was only 85 per cent. of the evaporation during the period of maximum load (Table X).

(To be continued.)

EXPERIMENTS FOR IMPROVING THE CONSTRUCTION OF PRACTICAL STANDARDS FOR ELECTRICAL MEASUREMENTS.

Report of the committee, consisting of Prof. CAREY FOSTER (chairman), Lord KELVIN, Profs. AYRTON, J. PERRY, W. G. ADAMS, and Lord RAYLEIGH, Drs. O. J. LODGE, JOHN HOPKINSON, and A. MUIRHEAD, Messrs. W. H. PREECE and HERBERT TAYLOR, Profs. J. D. EVERETT, and A. SCHUSTER, Dr. J. A. FLEMING, Profs. G. F. FITZGERALD, G. CHRYSTAL, and J. J. THOMSON, Messrs. R. T. GLAZEBROOK (secretary), W. N. SHAW, Dr. J. T. BOTTOMLEY and T. C. FITZPATRICK, Prof. J. VIRIAMU JONES, Dr. G. JOHNSTONE STONEY, Prof. S. P. THOMPSON, and Mr. G. FORBES. (Presented to Section A of the British Association, September 19, 1893.)

The work of testing resistance coils at the Cavendish Laboratory has been continued. A table of the coils tested is given. They have all been "ohms," as defined by the resolution of the committee given in their last report, and since adopted by the Board of Trade Committee on Electrical Standards in the following form:

The resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14·4521 grammes in mass, of a constant cross-sectional area, and of a length of 106·3 centimetres, may be taken as one ohm. The relation between the B.A. unit and the ohm is the following:

One B.A. unit = ·9866 ohm.

TABLE I.—Ohms.

No. of coil.		Value in ohms.	Temperature.
Nalder, 3,717	C.L.C. No. 361	—	—
Nalder, 3,874 ...	" No. 362	9·9926	14·9 deg.
Nalder, 3,059*	" No. 326	1·00000	16·5 "
Nalder, 3,633.	" No. 363	100·000	17·2 "
Nalder, 3 637	" No. 364	100·000	17·05 "
Nalder, 3,635	" No. 365	1,000·00	17·3 "
Nalder, 3,872	" No. 366	9·9947	14·9 "
Nalder, 3,873.........	" No. 367	9·9919	14·8 "
Nalder, 4,085.........	" No. 368	·99889	14·8 "
Nalder, 3,263 ...	" No. 369	·99895	14·2 "
Warden, 1,866	" No. 370	1·00080	14·5 "
Warden, 1,918	" No. 371	1·00041	14·3 "
Nalder, 3,715	" No. 372	·99944	13·5 "
Nalder, 3,719	" No. 373	·99907	13·3 "
Nalder, 3,720	" No. 374	·99898	13·3 "
Nalder, 3 633	" No. 375	9·9910	15·3 "
Nalder, 3,876..... ...	" No. 376	·99932	15·2 "
Nalder, 3,981 . .	" No. 377	10·0001	15·7 "
Nalder, 4,086	" No. 378	·99978	15·9 "
Elliott, 303	" No. 379	1·00054	18·2 "
Elliott, 304	" No. 380	1·00052	18·1 "

* This coil has been tested before.

The resolutions adopted by the committee at Edinburgh were communicated to the Electrical Standards Committee of the Board of Trade. After consideration the Board of Trade Committee drew up an amended report, in harmony with the Edinburgh resolutions, for presentation to the president (see Appendix I.).

The resolutions were accepted at Edinburgh by Dr. von Helmholtz on behalf of Germany, while in France an official committee decided last June to adhere to the propositions of the Board of Trade. Austria and Italy are connected by treaty with Germany for telegraph purposes, and in consequence adopt the same units.

Tests have been made during the year on the 1-ohm and 10 ohm standards of the association. These are still being continued. The 100-ohm and 1,000-ohm standards have now been delivered, and the tests will be shortly proceeded with. Some experiments were made as to the amount of heating in the coils produced by the current used for testing. These are detailed in Appendix II. Further valuable information on this point is contained in Mr. Griffiths's paper on "The Value of the Mechanical Equivalent of Heat."*

The committee think it desirable that they should be in a position to complete the set of resistance standards of the association, and recommend, therefore, that they be reappointed, with a grant of £25, that Prof. G. Carey Foster be chairman, and Mr. R. T. Glazebrook secretary.

The committee have learned with pleasure from Mr. W. H. Preece, one of the English delegates to the International Congress of Electricians at Chicago, that the congress has accepted a series of resolutions defining the fundamental units practically identical with the Edinburgh resolutions. Thus these resolutions have now been accepted as a basis for legislation throughout the British Empire, the whole of Western Europe, and the United States of America.

* Phil. Trans., 1893.

The committee are also informed that the Chicago Congress have adopted the name "henry" for the unit of self induction

While looking with favour on this suggestion, they think desirable to postpone definite action until the official report of the congress has been received.

In March, M Mascart wrote to the secretary, asking the opinion of the committee as to a name for the standard of resistance defined at Edinburgh. A circular letter was issued inviting members of the committee to express their views on four names which had been suggested—viz, international, normal, etalon, or "ohm de 1893." After receiving replies to the circular from 12 members of the committee, the secretary wrote to Prof Mascart to the effect that the number of members who expressed a preference for the name "international" was greater than the number declaring in favour of any other name, but that he thought that the committee would accept whichever of the first three suggestions commended itself to the French committee appointed to deal with the matter.

During the year, Dr. Muirhead has remeasured his standard condenser. He now finds as the capacity of a condenser, constructed 23 years since, to represent 1 microfarad (B.A.U.), the value ·9888 microfarad.

APPENDIX I.

Supplementary Report of the Electrical Standards Committee of the Board of Trade.

To the Right Hon. A. J. Mundella, M P., President of the Board of Trade.

Subsequently to the presentation of our former report to Sir Michael Hicks Beach, in July, 1891, we were informed that it was probable that the German Government would shortly take steps to establish legal standards for use in connection with electrical supply, and that, with a view to secure complete agreement between the proposed standards in Germany and England, the director of the Physico technical Imperial Institute at Berlin, Prof. von Helmholtz, with certain of his assistants, proposed to visit England for the purpose of making exact comparisons between the units in use in the two countries, and of attending the meeting of the British Association which was to take place in August in Edinburgh.

Having regard to the importance of this communication, it appeared desirable that the Board of Trade should postpone the action recommended in our previous report until after Prof Helmholtz's visit.

That visit took place early in August, and there was a very full discussion of the whole subject at the meeting of the British Association in Edinburgh, at which several of our number were present. The meeting was also attended by Dr. Guillaume, of the Bureau International des Poids et Mesures, and Prof. Carhart, of the University of Michigan, U.S A., who were well qualified by their scientific attainments to represent the opinion of their respective countries.

It appeared from the discussion that a few comparatively slight modifications of the resolutions included in our previous report would tend to secure international agreement.

An extract from the report of the Electrical Standards Committee of the British Association embodying the results of this discussion was communicated to us by the secretary, and will be found in the appendix to this report.

Having carefully reconsidered the whole question in view of this communication, and having received the report of the sub committee mentioned in resolution 14 of our previous report, we now desire, for the resolutions contained in that report, to substitute the following

Resolutions.

1. That it is desirable that new denominations of standards for the measurement of electricity should be made and approved by her Majesty in Council as Board of Trade standards.

2. That the magnitudes of the standards should be determined on the electromagnetic system of measurement with reference to the centimetre as unit of length, the gramme as unit of mass, and the second as unit of time, and that by the terms centimetre and gramme are meant the standards of those denominations deposited with the Board of Trade.

3. That the standard of electrical resistance should be denominated the ohm, and should have the value 1,000,000,000 in terms of the centimetre and second.

4 That the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14 4521 grammes in mass of a constant cross sectional area, and of a length of 106 3 centimetres, may be adopted as one ohm.

5. That a material standard, constructed in solid metal, should be adopted as the standard ohm, and should from time to time be verified by comparison with a column of mercury of known dimensions.

6. That, for the purpose of replacing the standard, if lost, destroyed, or damaged, and for ordinary use, a limited number of copies should be constructed, which should be periodically compared with the standard ohm.

7. That resistances constructed in solid metal should be adopted as Board of Trade standards for multiples and sub-multiples of the ohm.

8. That the value of the standard of resistance constructed by a committee of the British Association for the Advancement of Science in the years 1863 and 1864, and known as the British Association unit, may be taken as ·9866 of the ohm.

9. That the standard of electrical current should be denominated *the ampere*, and should have the value one tenth (0·1) in terms of *the centimetre, gramme, and second.*

10. That an unvarying current which, when passed through a solution of nitrate of silver in water, in accordance with the specification attached to this report, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of one ampere

11. That an alternating current of one ampere shall mean a current such that the square root of the time average of the square of its strength at each instant in amperes is unity

12 That instruments constructed on the principle of the balance in which, by the proper disposition of the conductors, forces of attraction and repulsion are produced, which depend upon the amount of current passing, and are balanced by known weights, should be adopted as the Board of Trade standards for the measurement of current, whether unvarying or alternating.

13 That the standard of electrical pressure should be denominated the volt, being the pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere.

13. That the electrical pressure at a temperature of 15deg. C. between the poles or electrodes of the voltaic cell known as Clark's cell, prepared in accordance with the specification attached to this report, may be taken as not differing from a pressure of 1 434 volt by more than 1 part in 1,000.

15. That an alternating pressure of one volt shall mean a pressure such that the square root of the time average of the square of its value at each instant in volts is unity.

16 That instruments constructed on the principle of Lord Kelvin's quadrant electrometer used idiostatically, and for high pressures, instruments on the principle of the balance, electrostatic forces being balanced against a known weight, should be adopted as Board of Trade standards for the measurement of pressure, whether unvarying or alternating.

(Signed)	Courtenay Boyle.	G. Carey Foster.
	Kelvin.	R. T. Glazebrook.
	P. Cardew.	J. Hopkinson.
	W. H. Preece.	W. E. Ayrton
	Rayleigh.	

(Signed) T. W. P. Blomefield, Secretary.

November 29, 1892.

Specification Referred to in Resolution 10.

In the following specification the term silver voltameter means the arrangement of apparatus by means of which an electric current is passed through a solution of nitrate of silver in water. The silver voltameter measures the total electrical quantity which has passed during the time of the experiment and by noting this time the time average of the current, or if the current has been kept constant, the current itself can be deduced.

In employing the silver voltameter to measure currents of about one ampere, the following arrangements should be adopted. The cathode on which the silver is to be deposited should take the form of a platinum bowl not less than 10 centimetres in diameter, and from four to five centimetres in depth

The anode should be a plate of pure silver some 30 square centimetres in area, and two or three millimetres in thickness.

This is supported horizontally in the liquid near the top of the solution by a platinum wire passed through holes in the plate at opposite corners To prevent the disintegrated silver which is formed on the anode from falling on to the cathode, the anode should be wrapped round with pure filter paper, secured at the back with sealing wax.

The liquid should consist of a neutral solution of pure silver nitrate, containing about 15 parts by weight of the nitrate to 85 parts of water.

The resistance of the voltameter changes somewhat as the current passes. To prevent these changes having too great an effect on the current, some resistance besides that of the voltameter should be inserted in the circuit. The total metallic resistance of the circuit should not be less than 10 ohms.

Method of Making a Measurement.

The platinum bowl is washed with nitric acid and distilled water dried by heat, and then left to cool in a desiccator. When thoroughly dry it is weighed carefully.

It is nearly filled with the solution, and connected to the rest of the circuit by being placed on a clean copper support, to which a binding screw is attached. This copper support must be insulated.

The anode is then immersed in the solution, so as to be well covered by it, and supported in that position; the connections to the rest of the circuit are made.

Contact is made at the key, noting the time of contact. The current is allowed to pass for not less than half an hour, and the time at which contact is broken is observed. Care must be taken that the clock used is keeping correct time during this interval.

The solution is now removed from the bowl and the deposit is washed with distilled water and left to soak for at least six hours. It is then rinsed successively with distilled water and absolute alcohol, and dried in a hot air bath at a temperature of about 160deg. C After cooling in a desiccator it is weighed again. The gain in weight gives the silver deposited.

To find the current in amperes, this weight, expressed in grammes, must be divided by the number of seconds during which the current has been passed and by ·001118.

The result will be the time average of the current, if during the interval the current has varied

In determining by this method the constant of an instrument, the current should be kept as nearly constant as possible and the readings of the instrument taken at frequent observed intervals of time. These observations give a curve from which the reading corresponding to the mean current (time-average of the current)

can be found. The current, as calculated by the voltameter, corresponds to this reading.

SPECIFICATION REFERRED TO IN RESOLUTION 14.

Definition of the Cell.

The cell consists of zinc and mercury in a saturated solution of zinc sulphate and mercurous sulphate in water, prepared with mercurous sulphate in excess, and is conveniently contained in a cylindrical glass vessel.

Preparation of the Materials.

1. *The Mercury.*—To secure purity it should be first treated with acid in the usual manner, and subsequently distilled in vacuo.

2. *The Zinc.*—Take a portion of a rod of pure redistilled zinc, solder to one end a piece of copper wire, clean the whole with glass paper, carefully removing any loose pieces of the zinc. Just before making up the cell dip the zinc into dilute sulphuric acid, wash with distilled water, and dry with a clean cloth or filter paper.

3. *The Zinc Sulphate Solution.*—Prepare a saturated solution of pure ("pure recrystallised") zinc sulphate by mixing in a flask of distilled water with nearly twice its weight of crystals of pure zinc sulphate, and adding zinc oxide in the proportion of about 2 per cent. by weight of the zinc sulphate crystals to neutralise any free acid.* The crystals should be dissolved with the aid of a gentle heat, but the temperature to which the solution is raised should not exceed 30deg. C. Mercurous sulphate, treated as described in 4, should be added in the proportion of about 12 per cent. by weight of the zinc sulphate crystals, and the solution filtered while still warm into a stock bottle. Crystals should form as it cools.

4. *The Mercurous Sulphate.*—Take mercurous sulphate, purchased as pure, and wash it thoroughly with cold distilled water by agitation in a bottle; drain off the water and repeat the process at least twice.* After the last washing drain off as much of the water as possible.

Mix the washed mercurous sulphate with the zinc sulphate solution, adding sufficient crystals of zinc sulphate from the stock bottle to ensure saturation, and a small quantity of pure mercury. Shake these up well together to form a paste of the consistence of cream. Heat the paste, but not above a temperature of 30deg. C. Keep the paste for an hour at this temperature, agitating it from time to time, then allow it to cool; continue to shake it occasionally while it is cooling. Crystals of zinc sulphate should then be distinctly visible, and should be distributed throughout the mass; if this is not the case, add more crystals from the stock bottle, and repeat the whole process.

The method ensures the formation of a saturated solution of zinc and mercurous sulphates in water.

Contact is made with the mercury by means of a platinum wire about No. 22 gauge. This is protected from contact with the other materials of the cell by being sealed into a glass tube. The ends of the wire project from the ends of the tube; one end forms the terminal, the other end and a portion of the glass tube dip into the mercury.

To Set up the Cell.

The cell may conveniently be set up in a small test tube of about two centimetres diameter, and six or seven centimetres deep. Place the mercury in the bottom of this tube filling it to a depth of, say, 1·5 centimetre. Cut a cork about ·5 centimetre thick to fit the tube; at one side of the cork bore a hole, through which the zinc rod can pass tightly; at the other side bore another hole for the glass tube which covers the platinum wire; at the edge of the cork cut a nick, through which the air can pass when the cork is pushed into the tube. Wash the cork thoroughly with warm water, and leave it to soak in water for some hours before use. Pass the zinc rod about one centimetre through the cork.

Clean the glass tube and platinum wire carefully, then heat the exposed end of the platinum red hot and insert it in the mercury in the test tube, taking care that the whole of the exposed platinum is covered.

Shake up the paste and introduce it without contact with the upper part of the walls of the test tube, filling the tube above the mercury to a depth of rather more than two centimetres.

Then insert the cork and zinc rod, passing the glass tube through the hole prepared for it. Push the cork gently down until its lower surface is nearly in contact with the liquid. The air will thus be nearly all expelled, and the cell should be left in this condition for at least 24 hours before sealing, which should be done as follows:

Melt some marine glue until it is fluid enough to pour by its own weight, and pour it into the test tube above the cork, using sufficient to cover completely the zinc and soldering. The glass tube should project above the top of the marine glue.

The cell thus set up may be mounted in any desirable manner. It is convenient to arrange the mounting so that the cell may be immersed in a water bath up to the level of, say, the upper surface of the cork. Its temperature can then be determined more accurately than is possible when the cell is in air.

In using the cell sudden variations of temperature should as far as possible be avoided.

Notes.

The Zinc Sulphate Solution.—The object to be attained is the preparation of a neutral solution of pure zinc sulphate saturated with $ZnSO_4 \cdot 7H_2O$.

At temperatures above 30deg. C. the zinc sulphate may crystallise out in another form. To avoid this 30deg. C. should be the upper limit of temperature. At this temperature water will dissolve about 1·9 time its weight of the crystals. If any of the crystals put in remain undissolved, they will be removed by the filtration.

* See Notes.

The amount of zinc oxide required depends on the acidity of the solution, but 2 per cent. will in all cases which will arise in practice with reasonably good zinc sulphate be ample. Another rule would be to add the zinc oxide gradually until the solution became slightly milky. The solution when put into the cell should not contain any free zinc oxide. If it does then when mixed with the mercurous sulphate, zinc sulphate and mercurous oxide are formed. The latter may be deposited on the zinc, and affect the E.M.F. of the cell. The difficulty is avoided by adding, as described, about 12 per cent. of mercurous sulphate before filtration. This is more than sufficient to combine with the whole of the zinc oxide originally put in if it all remains free. The mercurous oxide formed, together with any undissolved mercurous sulphate, is removed by the filtration.

The Mercurous Sulphate.—The treatment of the mercurous sulphate has for its object the removal of any mercuric sulphate, which is often present as an impurity.

Mercuric sulphate decomposes in the presence of water into an acid and a basic sulphate. The latter is a yellow substance—turpeth mineral—practically insoluble in water; its presence, at any rate in moderate quantities, has no effect on the cell. If, however, it is formed the acid sulphate is formed also. This is soluble in water, and the acid produced affects the E.M.F. The object of the washings is to dissolve and remove this acid sulphate, and for this purpose the three washings described in the specification will in nearly all cases suffice. If, however, a great deal of the turpeth mineral is formed it shows that there is a great deal of the acid sulphate present, and it will then be wiser to obtain a fresh sample of mercurous sulphate rather than to try by repeated washings to get rid of all the acid.

The free mercury helps in the process of removing the acid, for the acid mercuric sulphate attacks it, forming mercurous sulphate and acid, which is washed away.

The cell may be sealed in a more permanent manner by coating the marine glue, when it is set, with a solution of sodium silicate and leaving it to harden.

APPENDIX.

August 12th, 1892.

Dear Sir,—I am desired by the Electrical Standards Committee of the British Association to communicate to the Electrical Standards Committee of the Board of Trade the enclosed extract from their report made to the Association on August 9th, 1892.

I remain, yours faithfully,
(Signed) R. T. GLAZEBROOK,
Secretary, Electrical Standards Committee
of the British Association.

To Sir Thomas Blomefield,
Secretary, Electrical Standards Committee
of the Board of Trade.

EXTRACT FROM THE REPORT OF THE ELECTRICAL STANDARDS COMMITTEE OF THE ASSOCIATION, AUGUST 9TH, 1892.

The following resolutions were agreed to:

1. That the resistance of a specified column of mercury be adopted as the practical unit of resistance.

2. That 14·4521 grammes of mercury in the form of a column of uniform cross section 106·3 centimetres in length at 0deg. C. be the specified column.

3. That standards in mercury or solid metal having the same resistance as this column be made and deposited as standards of resistance for industrial purposes.

4. That such standards be periodically compared with each other, and also that their values be redetermined at intervals in terms of a freshly set up column of mercury.

It was further agreed that these resolutions be communicated to the Electrical Standards Committee of the Board of Trade.

With regard to the units of current and E.M.F. it was agreed that the number ·001118 should be adopted as the number of grammes of silver deposited per second from a neutral solution of nitrate of silver by a current of one ampere, and the value 1·434 as the E.M.F. in volts of a Clark cell at 15deg. C.

Dr. von Helmholtz expressed his full concurrence in these decisions, which are, as he informed the committee, in accord with the recommendations which have already been laid by the Curatorium of the Reichsanstalt, as well as by himself, before the German Government.

APPENDIX II.

Experiments on the Effects of the Heating produced in the Coils by the Currents used in Testing. By R. T. GLAZEBROOK.

Various circumstances (notably the experiments of Mr. Griffiths*) had made it appear probable that the heating effect in the coils produced by the current used in making the resistance test might be sufficient to affect the results of the tests. Some experiments were made to examine the point directly.

The resistance of a coil of 100 ohms (nominal value) was measured in the usual way—*i.e.*, by making a Wheatstone bridge of four coils whose nominal values were 1, 10, 10, and 100 ohms. If the coils had been accurate there would have been a balance; as it was, one of the 10 ohm coils needed to be shunted, and the adjustment was made by determining the value of the shunt when no current passed through the galvanometer.

As the current in the battery circuit was increased by varying the number of cells this shunt decreased in value, showing that the effect of the heating was to produce an apparent diminution

* *Phil. Trans.*, 1893.

of the resistance of the 1,000-ohm coil. This, of course, is as would be anticipated, for ten-elevenths of the current goes through the 1-ohm and one of the 10-ohm coils, the remaining one-eleventh goes through the 10-ohm and the 100-ohm. The rise of temperature will clearly be greatest in the first 10-ohm coil, and to counterbalance the increase in resistance produced thereby it becomes necessary to reduce the shunt. The following readings were obtained:

Current in amperes.	Shunt in 1,000 ohms.	Correcting factor.
·06	32·5	1·00028
·09	32·5	·00031
·12	*30	·00033
·14	30·5	·00033
·15	29·5	·00034

* Only one observation at this current was made; the others are the mean of several.

The true value of the 100 ohm is given by taking the product of the values of the two 10-ohm coils at the temperature of the observations, dividing by the value of the 1-ohm and multiplying by a factor representing the effect of the shunt.

During the above observations the temperatures remained steady, the factor changed from 1·00028 to 1·00034. Thus the resistance of the 100-ohm coil changed by ·031 – ·028, or ·006 ohm.

The apparatus was not sensitive with a smaller current; the effect, however, will vary as the square of the current and since trebling the current produces so small a change, we may infer that the total effect is itself small.

Another coil gave the following results:

Current in amperes.	Shunt in 1,000 ohms.	Correcting factor.
·05	48	1·000208
·09	45	·000222
·12	43	·000233
·14	41	·000244
·15	40	·000250

indicating a change in the measured resistance of ·0042 ohm on 100 ohms.

It is clear, therefore, that the effect of heating is small, though appreciable when currents approaching ·15 ampere are used.

ELECTRIC LIGHTING OF PETERBOROUGH.

We have received a copy of the report on electric lighting presented to the Town Council of Peterborough by Mr. J. C. Gill, A.M.I.C.E., the waterworks engineer to the Corporation. The report, which is addressed by Mr. Gill to the mayor, aldermen, and councillors, is as follows:

In accordance with your instructions, I have the pleasure to submit for your consideration the following report upon the application now before you of the Midland House to House Electricity Company for your consent to supply electricity within the borough of Peterborough.

Mode of Procedure.—Before going into the general question of the advisability of the Corporation themselves applying for a provisional order, it may be well to point out the mode of procedure to be adopted in making such application. It is laid down by law that "the application must be made in pursuance of a resolution passed at a special meeting of the local authority, after one month's previous notice of the same, and of the purpose thereof. The notice of application must be published in the months of October and November in two successive weeks in a local paper, and once in the *London Gazette*. The plans, etc., must be deposited on or before the 30th November with the clerk of the peace of the county and with the Board of Trade." It will thus be seen that with the month's notice before the meeting, and the advertisements after, as well as the preparation of the plans, etc., seven or eight weeks is the shortest time in which the regulations can be complied with; and in order to have all the requirements completed by November 30, the Council should decide upon its action in September, or, at the latest, early in October.

Area to be Lighted.—If the Corporation decide to apply for a provisional order the whole of the borough would be the area over which the powers would extend, but a "compulsory area," to be lighted within two years from the confirmation of the order, must be scheduled. This area would be the central portion of the town, and the mains would be extended outside its boundaries as required. The compulsory area may be large or small, at the will of the Council, but I would recommend the following streets as being suitable, viz., Westgate, Midgate, Long causeway, Market place, Church street, Cowgate, Queen street, Exchange street, Cumbergate, Cross street, Priestgate, Wentworth street, Narrow street, Bridge street, Bridge, and Bridge place.

Estimate of Cost.—In designing a central station for the supply of electricity, it is necessary to make provision for future extensions, and the first installation is thereby rendered more costly than if it were complete in itself. The buildings would provide for these future requirements, and in the buildings so designed I would recommend plant being erected capable of maintaining an output of 180,000 watts—equal to a constant lighting power of 51,500 candles. The system most suitable for supplying Peterborough is by continuous current at low pressure, and in my estimate I have adopted this system with accumulators. It is not the cheapest system, but for compact areas it is the best. I have provided for three compound steam engines, each driving a dynamo; and any two of these sets would be able to produce the current mentioned, while the third set was lying by. The total cost of buildings, engines, dynamos, accumulators, mains, switchboards and instruments required for making this installation complete I estimate at £12,500. The annual cost of maintenance when in full work, employing a working staff of nine hands and consuming 300 tons of coal per annum, would be (including management and office expenses) about £1,091, and adding interest on capital at the rate of 5 per cent. an annual return of £1,716 would be required.

Estimate of Income.—For the purpose of this estimate I have assumed that the charge to be made for current will be at the rate of 6d. per unit. At this price it will be necessary to sell 69,000 units per annum to make a return of 5 per cent. on the capital outlay, and pay the full working expenses. In Peterborough the consumption would probably average 30 units for each 16-c.p. incandescent lamp, and, therefore, it would be necessary to have 2,300 lamps connected. I believe, from enquiries I have made, that this number of lights would be subscribed for within a reasonable time, and that in a few years the electricity works would be earning such profits as to make them a very valuable property. With regard to this estimate of income, it must be borne in mind that until the lamps specified are at work the annual expenditure will not be nearly so much as stated. Half the staff and half the coal would suffice for supplying 1,200 lamps, and with this number only the works should pay their way. Then when the number of 2,300 is reached the maximum expenditure, with 5 per cent. interest, will be returned, and from this point onwards the income from additional lamps will be nearly all clear profit.

Cost Compared with Gas.—Electricity is usually sold by the Board of Trade unit, which is thus defined by Act of Parliament: "The expression 'unit' shall mean the energy contained in a current of 1,000 amperes flowing under an E.M.F. of one volt during one hour." One Board of Trade unit (or "kilowatt," as it is sometimes called), will keep an ordinary 10-c.p. incandescent lamp alight for 30 hours, or it will keep 30 of such lamps alight for one hour. The charge per unit varies in different towns from 4½d. to 8d., and could doubtless be sold in Peterborough at 6d. Taking, then, the cost of electric current at 6d. per unit, a 10-c.p. incandescent lamp would cost one-fifth of a penny per hour, which is the cost of a 5ft. gas burner at 3s. 4d. per 1,000 cubic feet. Every 5ft. gas burner could therefore be replaced with a 10-c.p. electric lamp at the same cost for current as paid for gas. Too much importance should not be attached to the relative prices of gas and electricity, because the quality of the commodity is in no way comparable. A great demand has been found for the electric light where gas of high quality is supplied at 2s. 2d. per 1,000ft., and where, consequently, the cost of electric lighting is very much higher than that of gas lighting.

Prospects of Cheaper Lighting.—There is a widespread idea that the plant for generating electricity is growing less costly year by year. This is not so. Buildings, boilers, steam engines, dynamos, and cables all cost as much now as they did when I prepared an estimate for you three years ago, and will probably cost as much three years hence. It is the current that has been cheapened, and that because of the increased output. When the quantity of units generated by the same plant is doubled, the cost per unit is considerably reduced, and can be sold at a less price. Thus the stations that have been running for some years and have got their plant working nearer to its full load, can bring down their charges from time to time, and in this way only is the generation of electricity becoming cheaper. The manufacture of all appliances used in central station works is now free and open, excepting only incandescent lamps, and in three months' time lampmaking will also be a free industry. There is therefore nothing to be gained by waiting, but, on the other hand, the sooner the works are in operation the sooner will they be earning a profit. The free trade in lamps will probably reduce the cost of electric light to the consumer, for besides getting the lamps at about one-third their present price, lamps are offered for delivery in November which are much more economical in the amount of current required per candle power.

Conclusion.—There is undoubtedly a strong desire amongst the commercial community of the city to adopt the electric light, and this is evidently the outcome of seeing the advantages derived from using electricity in other towns. There is also sufficient evidence that the local authority is the proper body to undertake the monopoly of supply. The Board of Trade regulations, very properly, make it impossible to have competition, but they give the local authority option of undertaking the supply themselves before granting powers to any company. Local authorities for some years held aloof from electric lighting, declining to go into any speculative business with ratepayers' money, and out of the first £4,500,000 invested in this industry only £474,000 belonged to local authorities. Now, however, the local authorities have realised that the supplying of electricity is a sound and profitable business, and the proportions of money expended are reversed, for out of works recently decided upon in 23 towns, costing in all £821,000, £796,000 are provided by the local authorities and only £25,000 by companies. The advantages of having any electricity supply works that may be established in Peterborough in your own hands are too obvious, and have been too often discussed to need recapitulating here, but I might point out that obtaining a provisional order does not bind you to carry out the powers granted, as the order may, if desirable, be afterwards transferred to a company. I am, however, so strongly convinced that the future of electricity supply undertakings will be profitable, that I feel justi-

fied in advising you to obtain the necessary powers in the ensuing session, and then proceed with the erection of some such central station as I have described. If, however, you should think the city would be better served by a company than the Corporation, I can safely say that you may, with every confidence as to the quality of work, allow powers to be taken by the company now seeking your consent. But if this is done, the company will be absolutely masters of the situation for 42 years, and I feel sure that a little consideration will show you that it must be for the benefit of the city that the Corporation should keep in their own hands the supply of electricity for all purposes. The successes attending municipal electricity works indicate clearly that there is everywhere a demand for this clean and wholesome light, and there is every reason to believe that when electricity works have been established in a town for 15 or 20 years, they will have obtained the same great value, as an investment, that gas and water works holds to-day.

For the reasons given in this report I submit (1) that the time has now come when the Town Council should decide either to apply for a provisional order themselves, or give their consent to the application of a company; (2) that in the best interests of the ratepayers they should obtain powers, and carry out electricity supply works themselves; (3) that they should commence with the central portion of the town, and instal a plant of about £12,500 capital cost.

ELECTRIC LIGHTING SCHEME FOR MONMOUTH.

In our issues of the 8th and 15th inst. we referred to the subjects of electric lighting and drainage as being under the consideration of the Monmouth Town Council, and to certain reports sent in to the latter authority. These reports were considered at a meeting of the Council on Friday, when the Mayor (Mr. W. Honeyfield) presided. The **Mayor** stated that at their last meeting he was authorised to form a small committee to examine the scheme foreshadowed and the statements he then made. This committee had met the electrical and sanitary engineers on the following Saturday, when instructions were given to examine and report upon the points put before them, and, if found practicable, to estimate for the cost. He would read their reports, and to enable them to consider the same ready for that day, he had made those extracts which were printed and distributed among them some days since. They had thus had an opportunity of considering the figures, and the scheme their committee recommended was the complete one, combining sewerage with the public and private lighting. The Mayor then read the following report:

REPORT OF THE BRUSH ELECTRICAL ENGINEERING COMPANY.

Our Mr. Dawbarn having inspected your borough and carefully examined local conditions affecting the question of electric lighting, we are now in a position to hand you herewith our report and suggestions as to the cost of (a) substituting 16 c.p. incandescent lamps for 95 gas lamps in existing lanterns belonging to your Corporation placed as at present; (b) extra for 11 additional lamps to replace oil lamps; (c) extra for installing plant large enough to maintain at one time 500 16 c.p. incandescent lamps for private consumers in addition to the whole of the street lamps; (d) auxiliary steam plant (equal to c), with spare dynamo, etc., as a stand-by to meet any emergency.

Power.—We thoroughly endorse the suggestion of yourself and Mr. Latley of utilising the natural power at your disposal, viz., the River Wye now running to waste, and have estimated accordingly. In Scheme A a turbine would be provided to develop 11 h.p., which would drive the sewage pump by day and the dynamo by night, maintaining the 100 or so street lamps. Under Scheme C we should require to develop 60 h.p., as against, say, 11 for the street lighting alone. The power we propose to obtain by means of two turbines, each to develop 30 h.p., which would together work upon the main shafting during the period of heavy load, say, from dusk to midnight, when one of them would be disconnected, as the other would be large enough to do all that would be required to meet the night load, including the street and private lighting, or the day load, comprising the sewage pumping, as well as any private lamps that might be alight in dark corners, etc. We do not propose at this stage to trouble you with minute details, but we may inform you that our estimates have been got out in complete detail, so that we shall be able to afford you any further information you may require at a later date without difficulty.

Alternator.—We may, however, be allowed to draw your attention to our Mordey Victoria alternator, which is the machine we recommend for your adoption. It is remarkable both for its simplicity of construction and its extremely high efficiency. We submit illustrations and a pamphlet describing our alternate current transformer system, which may be of interest. The usual pressure at which we work on the mains is 2,000 volts, but in this instance we propose only 1,000 volts.

Street Lamps.—The street lamps would be arranged in groups of 10 in series across the high pressure mains.

Private Lighting.—The private lighting would be effected by means of local transformers, to be placed either under the pavements, just outside the shop, or group of shops, or residences to be lighted, or in the basement of one of them. The arrangement of cables in our Scheme C admits of any private demand for incandescent lamps being met in the following streets to the extent of fully 500 16-c.p. lamps in all, without further outlay in mains: Wye Bridge-street, St. James's-street, Whitecross-street, Monk-street (as far as Priory-street), Church-street, Priory-street (from Agincourt-square to Market House), Agincourt-square, Monnow-street, St. Thomas's-square.

Transformers.—The transformer contains absolutely no mechanism, is enclosed in a watertight cast iron case, and is of extremely small dimensions. For instance, a 100-light transformer occupies a space not exceeding 2ft. × 1ft. × 1ft.; consequently there is no difficulty whatever experienced in actual working in disposing of these transformers conveniently for the lighting they control. The function of the transformer is to convert the pressure of 1,000 volts on the mains to 100 volts, which is suitable for private lighting and is absolutely harmless.

Mains.—The mains would be well insulated, sheathed with lead, further protected by taping, coated with special preservative compound, and laid directly in the ground in trenches provided by you. The above applies to the Schemes A and B, and to the small 10-light group conductors for the street lighting in Scheme C. The high pressure mains in Scheme C would, however, be drawn into iron pipes so as to admit of extension hereafter by drawing in larger cables in order to meet a growing demand from private consumers.

Auxiliary Plant.—If you undertake private lighting it will be absolutely necessary to provide against any possibility of interruption to the lighting, say through flood, which might prevent the turbines from working to their full advantage. We therefore quote under this section for spare plant, consisting of a vertical compound steam engine, locomotive boiler, and a spare alternator complete. We also provide a combination of fast and loose pulleys and clutches, so that the engine or either dynamo can be disconnected or connected to the main shafting at will. You will please understand that our tender does not include any building to accommodate the machinery, foundations for same, or cutting a canal for water supplied to turbines or race from them to the river, nor the construction of any works that may be required in the river itself. We are of opinion, after carefully examining the conditions, that a weir is not necessary, but it is possible that you may find it advantageous hereafter to construct a rough boulder type of weir for a few yards into the river, but this, if required at all, would be a trifling matter.

[Then follows a statement upon which the Corporation conclude that, while Mr. Latley's sewage scheme alone would cost £9,817 (adding £1,317 to the original cost for contingencies and fees) with an added annual cost of £150. 10s., which, allowing for repayment of principal and interest by 30 equal instalments at 3½ per cent., would necessitate a rate of 8½d. in the pound; in connection with public lighting, a rate of 7¾d. would only be required; and, further, by uniting the public and private lighting with the scheme, a rate at 5d. in the pound is estimated to meet the outlay. These facts are derived from carefully-prepared estimates as to expenses and anticipated revenue.]

The above estimates contain ample margins, and there is no reason whatever why your actual working expenses should exceed these amounts. You may therefore safely look to the larger plant to more than cover the working cost of your sewage scheme and leave a fair margin of profit. We desire to draw your attention to the fact that if you propose to take up your own powers for private lighting, it will be necessary for you to lodge your application to the Board of Trade before November 21 next in order to secure a provisional order in the ensuing session.

The **Mayor** then read the report by Mr. Latley on the sewerage question, and also a supplementary report, from which we abstract the following:

"I have seen the figures and calculations of Mr. Dawbarn compiled for the Brush Electrical Engineering Company, and so far as I am in a position to offer an opinion they appear to me to be correct. Having approved in general terms the mechanical arrangements which I understand are necessary for the proper and efficient carrying out of the scheme proposed by the Brush Electrical Engineering Company, I have to lay before you the following estimate. [Then follows estimate agreeing with that previously referred to.] It will be within your recollection that my preliminary estimate for the sewerage scheme was £8,500, but if the scheme as laid before you by the Brush Electrical Engineering Company is carried out in conjunction with my sewage scheme, there would be a reduction of from £800 to £1,000. I have carefully looked through the maintenance estimates of this company, and it appears that they show a profit which would cover the working expenses of the sewage scheme. In the event of your adopting the street-lighting scheme only, the expense of the waterway which is included in my sewage scheme would have to be increased to the extent of about £700.

Continuing, the **Mayor** said the figures given in the report showed a very favourable balance to the credit of the proposed scheme, but the question which arose in their minds, and in those of the ratepayers was, were the amounts reliable? He had heard frequently the opinion expressed that it would be a good thing if the thing could be done, but there seemed rather a doubt in the minds of the public, not as to its desirability, but possibility. He was firmly of opinion that the estimates given were fairly correct, and his ideas of its feasibility were confirmed by every enquiry. The figures of the electrical portion of the scheme were by the Brush Electrical Company, one of the most important companies in the kingdom in that branch of engineering, and were not an approximate estimate, but a tender for which they are prepared to do the work and guarantee its working. Those referring to the sewage part are by Mr. Latley, and are based upon work of the same kind in hand, and being carried out at the present time. He concluded his remarks with formally proposing the adoption of the report.

Councillor Cossens seconded the motion, which, after some discussion, was carried.

BUSINESS NOTES.

Coventry.—The Electric Light Committee of the Town Council has been established on a permanent basis.

Directory.—A new edition of the directory of the National Telephone Company for Scotland has just been issued.

Castleford (Yorks.).—The question of lighting the town by electricity is at present under the consideration of the Local Board.

Cork.—An electric light installation has been put up by Mr. Percival, of Cork, at the offices connected with Lady's Well Brewery, Cork.

A New Arc Lamp.—A new arc lamp, devised by Mr. H. Tipping, M.I.M.E., is being introduced by the Crown Electric Light Company, 80, Queen Victoria street.

St. Saviour's, Southwark.—The surveyor to the Board of Works has complained of inconvenience caused by electric lighting companies breaking up the asphalted thoroughfares.

Appointments Vacant.—The Bristol Corporation, as will be seen from our advertisement columns, require three assistant engineers for the municipal electric lighting station.

Fire Alarms.—The attention of the London County Council is to be directed by the Wandsworth Local Board to the insufficiency of fire alarms in the parishes of Tooting and Streatham.

Marchant, Young, and Co., Limited.—This Company has been registered, with a capital of £4,000 in £1 shares, to establish and carry on the business of electrical and mechanical engineers.

Bournemouth.—A central telephone is to be fixed in the hall of the Municipal Buildings connected with the town clerk's, surveyor's, and sanitary inspector's offices. The rent will be £3 yearly.

Ryde.—The Town Council have resolved to apply for power to supply public or private lighting by electricity, and to get permission to borrow and raise the amount required for the electric lighting.

Lewisham.—The Works Committee of the District Board have under consideration the question as to whether the Crystal Palace District Electric Supply Company shall light the public streets by electricity.

Southport.—A member of the Town Council has decided to defray the cost of installing the electric light in the church of St. Simon and St. Jude immediately on the Corporation supply being available.

Copper.—Copper is still quiet, with a moderate demand both for electrical purposes and for marine engineering. In the Newcastle district tough copper varies from £46 to £46. 10s. according to quantities needed.

Bristol.—The Board of Guardians have received eight tenders for the electric light installation at St. Peter's Hospital, and that of Messrs. Willway and Sons, of St. Augustine's-parade, for £28. 9s. 6d., has been accepted.

Anglo American Telegraph Company.—The Directors have declared an interim dividend for the quarter ended September 30 of 12s. 6d. per cent. on the ordinary stock, and 25s. per cent. on the preferred stock, less income tax.

Mersey.—The Mersey Docks and Harbour Board have confirmed the recommendation of the Docks and Quays Committee to provide an electric light at the south side of the entrance to the Morpeth Lock, at an estimated cost of £200.

City of London Union.—The House Committee have had referred to them for consideration and report the question of laying on the electric light at the infirmary at Bow, where there is a large number of patients in bed night and day.

Chichester.—The Lighting Committee of the Town Council have reported the appointment of a sub-committee to interview the gas company's representatives, and that they have considered the question of electric lighting, but have not yet arrived at a decision.

Watford.—At a meeting of the Local Board last week, the clerk asked for a committee to be appointed to help him to prepare the necessary notices with regard to the application for a provisional order for electric light. Messrs. Lake and Andrews were appointed.

Appointment.—We understand that Mr. T. H. Aldridge has obtained an appointment with the Grand Junction Canal works at their pumping station at Tring. He qualified himself for the post in the works of Mr. Ronald A. Scott, M.R.I., Acton-hill, London, W.

French Telephone Company.—With regard to the recent dissolution of the Société Générale des Téléphones, it is announced that the scheme for the reconstruction of the Company has now been completed, and that it will be laid before the shareholders shortly for their approval.

South Africa.—The South African Public Works Corporation, Limited, comprises among its signatories the firms of Messrs. Black, Hawthorne, and Co., Gateshead; the Gloucester Railway Carriage and Waggon Company, Limited; and Messrs. Easton and Anderson, of Erith.

City and South London Railway Company.—The receipts for the week ending September 24 were £773, against £768 for the same period last year, or an increase of £5. The total receipts for the second half year of 1893 show an increase of £445 over those for the corresponding period of 1892.

Rawmarsh.—The Local Board have decided to reduce the price of gas. Before doing so, at a meeting last week, Mr. Spick said that there was a probability of their having the electric light in the district before long, and he thought it would be to the interest of the Board to make a reduction as soon as possible.

Electro Protector Syndicate, Limited.—This Company has been registered, with a capital of £10,000 in £1 shares, to adopt an agreement, made between R. Jewell of the one part and C. O. Greenwell, on behalf of this Company, of the other part, and to carry on business as electricians, mechanical engineers, etc.

Bolton.—The work of preparing the site in Spa-road for the proposed electric lighting depôt has been commenced this week, and is being rapidly pushed forward under the superintendence of Messrs. Hinnell and Murphy, architects, and Mr. Rider, electrical engineer. The laying of the mains will be proceeded with as quickly as possible.

Eastern Telegraph Company.—This Company announce the payment on October 13 of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum, on the preference shares for the quarter ending September 30, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income tax, in respect of profits for the quarter ended June 30.

Blackpool.—What is termed an "electrical *fête*" is to take place in a few days. At the electric lighting station all the dynamos for supplying the current for the arc lamps are now in readiness for running, and the electricity generated by one is being utilised for the arc lamps at the Winter Gardens. The total number of lamps to be erected along the Promenade is 73.

Guildford.—The Board of Guardians have referred to the House Committee a letter from the town clerk of Guildford, stating that the Council would have no objection to the telephonic connection of the union workhouse and the borough police station on condition that the whole of the expense was defrayed by the Guardians, and that an undertaking was given to remove the wires at any time on reasonable notice being given.

Bath.—When the Surveying Committee of the Town Council met last week, Mr. Sturges brought up a table which the Electric Lighting Committee had adopted, showing the hours at which the electric light would be switched on and off every evening and morning in the year. According to the table, the light would be switched on at 6.37 in the evening and off at 4.11 the next morning. It was decided to give a trial to the hours mentioned.

Yeadon.—The Yeadon Local Board have received a letter from Mr. R. Hammond, giving the terms on which he would prepare a scheme of electric lighting for Yeadon. The Board have decided to have another interview with Messrs. Andrews and Preece, of Bradford and Morecambe, and after that to call a public meeting for the purposes of asking the ratepayers' sanction to the Board undertaking the supply of electricity for both public and private lighting.

Electric Lighting at Wrexham.—On the 20th inst. a special meeting of the Town Council was held for the purpose of considering in committee a letter from Messrs. Lewis and Son, solicitors, stating that the Wrexham and District Electric Supply Company, Limited, were prepared, in accordance with the offer made by the chairman of the company to the Lighting Committee on April 25th, to sell to the Corporation the provisional order of the company for the sum of £500.

Meeting of Creditors.—A meeting of creditors of Selina Rowbottom, electrical engineer, of 82, Abbey street, Derby, carrying on business as S. Rowbottom and Co., has been held at Derby. The debtor's statement showed liabilities £302. 19s., of which £280. 4s. was expected to rank for dividend. The stock in trade, which cost £400, was estimated to realise £250, the machinery £36, trade fittings, etc., £25, furniture £20, and there were good book debts put down at £26. 10s. The alleged cause of failure was bad trade during the past year. The usual resolutions have been passed.

Lighting at Brighton.—As mentioned in our last issue, a considerable portion of the front—namely, from the western boundary to the Aquarium—has been lighted by electricity, the ceremony of switching on the current for the first time being performed by the Mayoress. The inaugural proceedings were very successful, and the electric light was seen to be a great improvement on the old system of lighting. Twenty out of the 40 lamps are put out nightly at 11 o'clock, the others being kept on till dawn. The difference in the cost as compared with gas is an annual increase of £300.

Weston-super-Mare.—At a meeting on the 11th inst. of the Inspection Committee of the Town Commissioners, Mr. Goode, of Messrs. Fowler and Co., of Leeds, waited on the committee to state that he would be willing to prepare and submit a scheme and estimate for fitting up an electric lighting station and laying down plant within the compulsory area. The committee explained that as the Board were now in negotiation with the Brush Electrical Engineering Company, Limited, they could not at the present time give his firm any instructions in the matter. The Commissioners are to hold a special meeting, when, among other matters, a letter from the Brush Electrical Engineering Company will be considered.

Halifax and Bermudas Cable Company.—The annual meeting was held at 33, Old Broad street last week. The report, which was adopted, stated that the year's working had resulted in a profit of £1,717, as compared with £1,261 for 1891-2. The balance of £1,682 brought forward made the sum to the credit of revenue £3,399. The net cable receipts were £4,856, as compared with £3,915. The loan of £9,000 from the Gresham Life Office at 6 per cent. has, since June 30th, been further reduced to £6,800, and the rate of interest to 5 per cent. The £10,153 which appeared in

the last balance-sheet as debit against capital account had been reduced to £6,754 by the application of the £3,399 to credit of revenue account. The fund for the redemption of the debentures is now £7,995 as compared with £5,175 last year.

New Installation.—On Monday night a numerous company assembled in the warerooms of Messrs. Robert Adams and Son, furnishing ironmongers, 14, East Maitland street, Edinburgh, for the purpose of seeing the electric light turned on in these premises. The work has been carried out under the superintendence of Mr. Mathew Buchan, electrical engineer, Portobello, and by an ingenious arrangement of lamps with coloured shades a most pleasing effect has been obtained. The engine is an Otto of 8.5 actual or brake horse-power, with two heavy flywheels. The dynamo is driven by one of the flywheels, a patent link leather belt specially adapted for such work being used. The dynamo, which is of special design, is constructed to light either arc or incandescent lamps, or of charging accumulators so that the lights may be turned on when the engine is not running.

Southampton.—When the Harbour Board met on the 19th inst. the Works Committee mentioned that an offer having been received from Messrs. Statter and Co. to supply some spare parts for electric cranes, at a cost of about £150, the offer was not entertained, though permission was given to the firm to make some tests as to the efficiency of these cranes, on the understanding that they would pay for the current supplied. Alderman Bone, in moving the adoption of the report, said that with regard to the electric cranes, an offer had been made by Messrs. Statter and Co. to supply some spare parts for the electric cranes at a cost of £150, but the committee felt there was no necessity for this, because they hoped to have the other crane working soon, and if anything happened to one the other could take its place until what was necessary had been done to it. The report was adopted.

Lighting at Dewsbury.—The Electric Lighting Committee of the Board of Guardians, after considering the tenders for lighting the workhouse, etc., have recommended the Board to formulate a specification based upon the several tenders, to provide for the lighting of the cottage homes, and to contain a clause guaranteeing the proper and effective lighting of the workhouse, etc., for a reasonable period thereafter, and that the tenderers submit tenders in accordance with such specification. Mr. Joseph Brown, at a meeting of the Board last week, said that the committee had gone very carefully into those matters, and had come to the conclusion that the cost of lighting the premises by electricity would be less than by gas. The minutes were passed, and it was resolved to apply for power to borrow £2,100 for the electric lighting of the premises. The Board have agreed that it be an instruction to the committee to prepare a specification for the complete lighting of the Board's premises, including the cottage homes.

Telegraphists' School of Science.—The eighteenth session of this school will be opened next week at the Central Telegraph Office, and the list of prizes gained by last year's students at the City and Guilds Institute and in the science and art examinations has been published. The names of the principal prizetakers are as follows: The City and Guilds Institute's Examinations: Telegraphy and Telephony: Honours grade, first prize in the United Kingdom, silver medal and £3, Mr. A. R. Nichols; first-class certificates, Mr. W. J. Bailey, Mr. A. J. Eames, Mr. A. R. Nichols, Mr. S. F. Pace, Mr. T. Pender, Mr. R. Nimmo, Mr. J. E. A. Sorrell, Mr. W. Stevenson, Mr. J. E. Taylor, and Mr. C. W. Wheeler. Ordinary grade: first prize in the United Kingdom, silver medal and £2, Mr. G. R. Adams; third prize in the United Kingdom, bronze medal and £1, Mr. C. G. Roach; first-class certificates, Mr. G. R. Adams, Mr. F. Barfield, Mr. A. J. Dawes, Mr. E. M. Draper, Mr. E. J. Eames, Mr. J. Kilford, Mr. H. Maguire, Mr. F. Morgan, Mr. C. G. Roach, Mr. T. Smerdon, Mr. C. J. Turner, Mr. E. W. J. Todd, and Mr. J. Wendon. The Science and Art Examinations—Magnetism and Electricity: Advanced stage, first class certificates, Mr. R. Nimmo, Mr. T. Pender, and Mr. J. E. A. Sorrell; second class certificates, Mr. G. R. Adams, Mr. A. R. Nichols, Mr. S. F. Pace, Mr. T. Smerdon, Mr. W. Stevenson, and Mr. C. W. Wheeler.

Huddersfield.—The rooms on the ground floor of the Technical School have been fitted up with the electric light by Messrs. Scott and Mountain, of Newcastle-on-Tyne, and last week the supply of electricity from the Corporation mains was formally turned on by Alderman J. F. Brigg, the president. Altogether about 125 incandescent lights have been distributed amongst the ground corridors and rooms, which comprise the weaving shed, the dyeing house, the chemical laboratories, and the chemistry, dyeing, and physical lecture rooms. These are departments of the school in which the improved light will be a great boon, proper colour being an important point in each. It is contemplated to extend the installation throughout the school. On the confirmation of the minutes of the Electric Lighting Committee of the County Council, Councillor Broadbent asked if anything had been done with regard to an exhibition of electricity. Councillor Marshall replied that if any manufacturer required to exhibit, and took a shop in the town, the committee would supply the light. The Central Wards Committee of the Town Council recommended, on the 20th inst., that St. George's square should be lit by electricity, and that four arc lamps should be erected. Alderman Brigg (chairman of the committee) said that no doubt if the experiment was successful the electric light would be more extensively used for the lighting of public thoroughfares. The recommendation was adopted.

Electric Lighting of Edinburgh.—A report on this subject has been presented by Prof. Kennedy to the Electric Lighting Committee of the Town Council. Pressure on our space compels us to postpone the publication of the report until next week. At a meeting of the Town Council on Tuesday, Mr. Mackenzie, at the request of the Lord Provost, made a statement as to the present position of the electric lighting question. On 16th May last, he said, the minutes were finally approved authorising the Corporation to proceed with an installation of the electric light. The matter was remitted to a sub-committee. It might appear to some present and to people outside that a great deal of time had been lost. Prof. Kennedy explained that a considerable amount of the preliminary work had to be rearranged in consequence of the decision of the Gas Commissioners not to supply gas for gas-engines at the rate for public lighting purposes, he having been in the belief that such a concession would be granted. In the circumstances, he had to begin over again, and this accounted for a considerable portion of the time that had elapsed. Recently, however, Prof. Kennedy had been instructed to prepare plans and specifications for the lighting of the compulsory area, and beyond that area, to the extent that he thought it would be judicious on the part of the Corporation to go. When these plans and specifications were ready, the committee would again approach the Council for their opinion as to going outside the compulsory area.

Electric Lighting at Lynton.—A correspondent writes that the electric light at Lynton and Lynmouth is not altogether a success. He states that during the winter months when the River Lyn is in full flood the electric light company have no difficulty in supplying a good current, but directly the river begins to get low the consumers of electricity suffer, showing that some additional power is required. For some time past it has been reported that the company intended using steam as an auxiliary when the water power failed, but up to the present time nothing has been done, despite the many complaints made by the consumers, and the utter impossibility to supply new customers (if they were forthcoming), after such experiences as have been witnessed during the past three years. Continuing, he says: If the present company do not care to incur the additional expense of extra machinery, perhaps the Local Board might be induced to consider the advisability of having the lighting of the two villages in their own hands, and eventually working it to the advantage of the ratepayers generally. Not only is a better light required, but complaints are numerous of the late hour when the current is put on, many householders having to use some other illuminant quite an hour before the electric light company think fit to lighten the darkness. The customers of the company will probably have something to say when the quarter's rent becomes due, but in a case like this, where individual complaints are not heeded, it would be well to remember that unanimity and determination may in the end do some good.

Electric Lighting of Derry.—The Corporation of Derry deserves credit for the business-like manner in which the scheme for the lighting of that city by electricity has been promoted and brought to its present position. The street lighting will be effected by arc lamps placed on the pillars that are being erected throughout the city. The system adopted by Mr. Blake, the consulting engineer to the Corporation, is continuous currents at high pressure, worked direct from the generating station. There will be two circuits in each street, and every alternate lamp will be placed on one of these circuits, so that one half of the lamps can be lighted or extinguished simultaneously. By a switch placed in the pillar each lamp can be extinguished separately. The city is divided into sections, east and west, and each section has its own distinct and separate circuits, dynamos, and machinery. All the city south-east of Shipquay-street and Bishop-street, including the waterside, will be supplied by its own distinct duplicate circuits from two of Siemens's constant-current dynamos, and all the city north-west of these streets will be supplied by different circuits from another pair of dynamos. A third set of dynamos is installed in the station as a stand-by. These six dynamos are each capable of running 60 arc lamps of 2,000 c.p., but as two of these will be held in reserve there will be in constant use four machines capable of running 240. The present contract is for the installation of 160 lamps. The arc lamps are of the Brockie-Pell type. The conductors are highly insulated copper cables, armoured, and laid directly in the ground. This extensive system of street lighting by electricity is being carried out by the Corporation without any additional tax on the ratepayers. It is estimated that the annual payment hitherto made to the gas company for street lighting will cover the repayments and interest of the loan of £15,000 granted by the Board of Works, and after the loan is paid off the cost of lighting the city by electricity will be only one-third of the cost of lighting it by gas. Everything is in a forward state. The generating station has been erected, the boilers are set, the machinery is in course of erection, and Messrs. Siemens Bros. and Co., Limited, are busily engaged in laying the underground cables and wiring the lamp pillars, and by end of next month it is expected that two of the circuits will be lighted and the other two circuits immediately after, so that the whole installation will be completed and working this winter. The Corporation is ready to undertake private lighting provided a sufficient number of ratepayers intimate their wish to be supplied.

Lighting at Killarney.—The Town Commissioners considered the question of public lighting at a meeting last week, Mr. J. Duckett occupying the chair. When the minutes of the last meeting were read, Mr. Moriarty stated that he attended through a notice served on him and on the town clerk by Mr. Leahy, cautioning him against drawing up any bond to be signed by Mr. Santry on the grounds that the resolution with regard to the gas tender was not put to the meeting, was not accepted, and that the meeting rejected the electric light tender, etc.; they did not at all consider the question of the gas tender. He came to have the instructions of the Board how he was to act in the matter. The

minutes showed that it was passed without a division, whatever that meant. Mr Haggard, solicitor, stated that the electric light company had put in a tender the last day for the lighting of the town, in pursuance of an advertisement. From what he heard he understood Mr M'Carthy urged there the last day that the tender did not state the names of the sureties proposed. As far as he could see from the advertisement, the latter did not require that at all. They (the electric light company) considered their tender was in proper order, as it should be in pursuance of the advertisement, and that being so, they asked to know, before the signing of the minutes of the last day, was the tender of the gas company accepted by resolution? They said it was not, and he was very glad it was not carried, because if it was they (the Commissioners) would have brought about this curious state of things in Killarney: that while the electric light company, in pursuance of an advertisement, tendered for a sum of £50, the Town Commissioners of Killarney, for the same light exactly as the gas, accepted the gas company's tender at the enormous sum of £92 10s. Now this was a very extraordinary state of things. He need not go back upon the history of the electric lighting question in the town. They might remark that when the electric light was first started, the Town Commissioners went so far themselves into the question that they applied to the Board of Trade for a provisional order to light the town with electricity, and now when the electric light was there, they gave the contract to the gas company at a far higher price. He understood they proposed to charge £2 10s. for each public lamp in the town, while the electric light company tendered for £2. He would ask them to postpone signing the minutes, if they were not strictly in accordance with the facts, and they did not appear to be. He could form no reason why the electric light company's tender was not accepted. He had heard that it was stated by Mr Leonard that the electric light company was a bogus company, and asked the Town Commissioners not to contract with any English company. He (Mr Haggard) knew a great deal about the electric light company, and certainly it was not a bogus company. The Commissioners themselves knew this when they were fighting the question before the Board of Trade. There was more Kerry money in it than in the gas company. It was a local company, and deserved local support. If they could supply light to the Town Commissioners cheaper than the gas company, they asked for fair play. If they could supply it at half the price, they demanded it as a right. If the Town Commissioners didn't wish to do so it would be a question upon which the ratepayers of Killarney might have an opinion to express, and he came there to say that their giving the contract to the gas company the last day was not carried at once. The clerk (Mr. M. Healy) stated that as regards the signing of the minutes that day the present chairman had nothing to say to them. The chairman who presided last day was responsible for them, and would sign them when he liked. The chairman last day was Mr T. T. O'Connor, who now declined to sign the minutes. After further discussion, on the motion of Mr Hurley, seconded by Mr. Brosnan, the following resolution was adopted: "Resolved, that we protest against the minutes, as they do not contain a resolution accepting the tender of the Killarney Gas Company, which was not put to the vote."

PROVISIONAL PATENTS, 1893.

September 18.

17501. **Improvements in and connected with alarum clocks, and electrical signalling appliances.** Walter Fielder, 57, Shakespeare road, Herne Hill, Surrey.

17521. **An improved method of illuminating by the electric arc.** James Jackson and Walter Dixon, 27, Sandyford place, Glasgow.

17526. **Improvements in or relating to fac-simile telegraphy.** Richard Joseph Crowley and Harry William Charles Cox, Harbour road, Queenstown, Ireland.

17557. **Improvements in electric motors.** Edmond Commelin, 6, Lord street, Liverpool.

17564. **Improvements in electric accumulators.** Adolf Koch, 23, Southampton buildings, Chancery-lane, London. (Complete specification.)

September 19.

17603. **Arc lamp.** Arthur Stanley Atwater, 52, Chancery-lane, London. (Complete specification.)

17605. **Improvements in dynamos and dynamo motors.** William Spiers Freeman, Invicta Works, Otford, Kent.

17618. **Improvements in electric motors.** Carl Erben and E. Bergmann, 6, Lord street, Liverpool.

17631. **Improvements in and connected with alarm clocks and electric sound signalling appliances.** Henry Newmarch, 166, Fleet street, London.

17645. **Improvements relating to the distribution and regulation of electric current.** Hubert Henry Grenfell and Octavius March, 45, Southampton-buildings, Chancery-lane, London.

17646. **Improvements in telephone switch operating mechanism.** Thomas Wood Ness, 46, Lincoln's-inn fields, London. (Complete specification.)

17658. ***Improvements in current conveyors for electric railways.*** *Reginald Walter Barker, Monument chambers, King William street, London. (The Lawrence Electric Company, United States.)* (Complete specification.)

September 20.

17666. **Lithophanique porcelain shades for the electric light.** William Isaiah George Lewis and Edgar James Bradley, 18, Chester street, Newcastle-on-Tyne.

17690. **In or relating to the transmission of electricity and sound along a conductor without a return circuit and a means of reducing electrical resistance in the air, earth, or sea.** Richard Joseph Crowley, Harbour row, Queenstown, Ireland.

17692. **An electric match.** Emile Coustau, 23, Plato road, Brixton, London.

17729. **An improved convertible combination lamp for electric light, gas, oil or candle fittings for general advertising.** Alexander Kelvie, 78, Adelaide road, Brockley, London.

September 22.

17796. **Improvements in electric arc lamp regulators.** Rankin Kennedy, 1, Clifton villas, Camden square, London.

17804. **Improvements in or connected with secondary batteries.** Francis Louis Berners and John Limbrey Higgs, 54, Fleet street, London.

17830. **A new and improved galvanic battery to be called a cartridge-shell battery.** George Abbott, 57, Pantiles, Tunbridge Wells. (James John Pearson, United States.)

17850. **Improvements in electrically propelled vehicles.** Ernest John Cotton and Alfred William Southey, 53, Chancery-lane, London.

17866. **An improved manufacture of electric accumulators.** Ludwig Wilhelm Schaller and George Ernst Wilhelm Scheffer, 45, Southampton buildings, Chancery-lane, London.

17867. **Improvements in apparatus for the electrolytical decomposition of brine and other liquids.** Herbert Guthrie and Malcolm Guthrie, 16, Lincoln's-inn fields, London.

September 23.

17874. **Improvements in globe holders for gas, oil, or electrical purposes.** Howard Walker, 12, Cherry-street, Birmingham.

17933. **Automatic supply fuse for electric supply currents, and in apparatus connected therewith.** James Hopwood, 11a, Cargill-road, Earlsfield, London.

SPECIFICATIONS PUBLISHED.

1892.

16315. **Electric telegraphs.** Bowen.

17093. **Electrostatic measuring instruments.** Ayrton and Mather.

18357. **Electrical switches.** Wyand and Schramm.

19184. **Electric lamps.** Imray. (Westinghouse Electric and Manufacturing Company.)

19404. **Cut-outs for electric generators, etc.** Raworth.

19821. **Current transformers.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

19834. **Telephonic apparatus.** Bennett.

20700. **Lighting trains by electricity.** Jones.

21243. **Electric light cables and lamps.** Webb and Thompson.

22038. **Incandescent electric lamps.** Cathrow.

23579. **Electric incandescent lamps.** Zobel and Buchmüller.

1893.

206. **Producing light by alternating electric currents.** Salomons and Pyke.

2331. **Secondary batteries.** Edgerton.

5987. **Telephone, etc., circuits.** Fletcher.

9262. **Electric meters.** Ericsson.

13066. **Electric incandescent lamps.** Boult. (Stoner.)

13858. **Galvanic element.** Heil.

13911. **Heating, etc., metals electrically.** Thompson. (Coffin.)

14076. **Electric measuring instruments.** Lake. (Armen.)

14474. **Telephone circuits.** Forbes.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
City of London	—	11
— Pref.	—	12¼
Electric Construction	—	
Gatti's	—	5¼
House to House	5	5¼
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¼
London Electric Supply	5	1
Metropolitan Electric Supply	—	6¼
National Telephone	5	4½
St. James', Pref.	—	8
Swan United	3¾	3¼
Westminster Electric	—	5¼

NOTES.

Burmah.—A further extension of telegraphs is to be made in Upper Burmah.

New Arc Lamp.—A new arc lamp, termed "Progress," has been brought out in Paris.

Leeds.—The entire tramway system is expected shortly to pass into the hands of the Corporation.

Cambridge.—Lord Kelvin is to open the new science buildings at the Leys School on 28th inst.

Obituary.—The death occurred on Monday of Sir Stevenson Arthur Blackwood, secretary to the General Post Office.

Madras Tramways.—The plans for the construction of the electric tramways have been approved by the Government.

Pelican Club.—The National Telephone Company have taken over the old premises of the Pelican Club in Gerrard-street, Soho.

Telegraph to Gilgit.—The new line from Bundipur to Gilgit has been erected to within four miles of the highest part of the Burvil Pass.

Leicester Tramways.—The Town Council have instructed a committee to report on the subject of acquiring and working the tramways.

Railway Carriage Lighting.—Extensions in the lighting of the carriages of the Paris, Lyons, and Mediterranean Railway Company are in progress.

London-Paris Telephony.—No less than 150 words per minute can, it is said, be transmitted along this line in the French language, as compared with only 90 words per minute in English.

Rothwell.—A dispute between gas users and the gas company has led the former to dispense with gas for the present. This should lead to the question of electric lighting being considered.

Geneva.—An international electrical exhibition is spoken of in Geneva for 1896. This exhibition would be opened at the same time as the starting of the new municipal hydraulic and electric works.

Gilchrist Lectures.—The first of the Gilchrist lectures on science, in connection with the Bethnal Green Free Library, was delivered last week by Prof. V. B. Lewes on "The Atmosphere and its Relation to Life."

London School Board.—The new building of the London School Board on the Thames Embankment is lighted throughout by electricity, and the Council-chamber is ventilated by means of a fan driven by an electric motor in the central turret of the roof.

Birmingham Cars.—A suggestion having been made by a correspondent that the tramcars on the Bristol-road line should be operated on the overhead trolley system, other correspondents of Birmingham papers have written objecting to the system as being unsightly.

Telephony.—Telephone lines are being established between Leeds and Hull, London and Brighton, Swansea and Cardiff, Cardiff and Newport, Newcastle and Hexham, Newcastle and Morpeth, and Glasgow and Belfast. The entire system will consist of metallic circuits.

Military Telegraphy.—The War Department authorities have given instructions for telegraphic communication to be established between Sheerness Garrison and the new battery recently constructed at Barton's Point, which forms the outwork of the military defences for the protection of the entrances to the River Thames and Medway.

City of Manchester Tenders.—With regard to the advertisement printed on page iv. for the supply of electrical plant, the date for sending in tenders is 17th October, and the words "Town Hall, Manchester, 29th September," should read "Town Hall, Manchester, 5th October." This, then, makes the "17th inst." to be correct.

A Lady Electrician.—The first woman to receive the degree of electrical engineer was Miss Bertha Lampre, of Springfield, Ohio. She was "high man of her class" all through the course in the Ohio State University, and has proved herself practical as well as scientific by securing a position with the Westinghouse Electric Company at Pittsburg.

Union of German Electrical Engineers.—Dr. Slaby, of Berlin, presided at the first annual meeting of this society, held at Cologne last week. It was mentioned that no less than 762 persons had become members of the union, these including not only those engaged in the electrical industry, but also representatives of local authorities.

Train-Lighting.—In a note dealing with defective lighting of railway carriages the *Lancet* states: "Our protest is in the interest of the public and of the eyes of our patients, but the interest of the railways and the omnibus companies would also surely be served by the reform, and we strongly advise the public to patronise the company that is most generous in the matter of providing efficient light."

A Brilliant Meteor.—On Sunday evening a meteor of extraordinary brilliancy was seen at Leicester. It seemed to burst from near the zenith, and proceeded towards the western horizon, increasing very rapidly in brilliancy, until the ground and atmosphere were lit up as by an electric lamp of great power. Objects in the landscape could be clearly seen at a long distance for several seconds, and then the meteor disappeared.

Vulcanised Fibre.—A pamphlet has been issued by Messrs. Mosses and Mitchell, of Chiswell-street, London, E.C., concerning the patent vulcanised fibre supplied by the firm. Hard vulcanised fibre is largely used by makers of electrical instruments in place of vulcanite, ebonite, etc., and in dynamos for commutators, magnet heads, for switchboards, insulators, press buttons, etc. Tubes are likewise made of this material, as are also valves for air and circulating pumps.

Books Received.—"A Manual of Telephony," by W. H. Preece, F.R.S., and A. J. Stubbs; second edition, price 15s. "Electric Lighting and Power Distribution—Part II.," by W. P. Maycock, M.I.E.E., price 2s. 6d. "The Principles of Fitting," by a Foreman Patternmaker, price 3s. 6d. The above books have just been issued by Messrs. Whittaker and Co. "The Design of Alternate-Current Transformers," by R. W. Weekes, Whit.Sch., Assoc.M.Inst.C.E., price 2s., is just issued by Messrs. Biggs and Co.

Towing by Electricity.—Reference was made to this subject in a previous issue, and we now learn that an appropriation has been voted in New York State for carrying on experiments in towing on canals by means of electricity, and that the Superintendent of Public Works has arranged for some practical tests. Poles are to be erected on each side of the canal at Pittsford to suspend trolley wires which are to be strung over the middle of the waterway. The current will be collected in the ordinary manner.

Continuous from Alternating Currents.—Before the recent meeting of the Union of German Electrical Engineers, Mr. Pollak described an apparatus for converting alternating current to direct current, and for utilising the latter for charging accumulators. He claimed to obtain by the use of this apparatus an efficiency of 98 per cent., or a loss in conversion of only 2 per cent. He suggested that the adoption of this system would be advantageous for the working of electric tramways.

Telephony at Manchester.—The National Telephone Company is getting vexed with the Manchester Corporation with regard to underground wires. The company is anxious for the Town Council to come to a speedy decision on the subject, because it is alleged the work cannot be further delayed without danger of the dislocation of the telephone service. If facilities are not granted for placing the wires underground, the company threatens to duplicate the overhead wires. The cost to the company of reconstructing the system underground will be £40,000.

Morley Memorial College.—The honorary secretary of the Morley Memorial College for Working Men and Women, Waterloo-road, S.E., desires us to draw attention to new classes and lectures now commencing. A course of 10 lectures will be given on "The English Citizen" by Mr. Graham Wallas, M.A.; classes have been arranged in "Steam" and "Heat" in connection with the Science and Art Department, and in foreign languages, building and machine construction, political economy, etc. A prospectus can be obtained of the honorary secretary at above address.

An Electrical Fete.—As mentioned in our last issue, the Blackpool Town Council have decided to hold an "electrical *fête*" on the 18th inst. The arc lamps along the promenade will be lit for the first time, and it is proposed to festoon the whole length with incandescent lamps. The tower will be outlined from top to bottom with incandescent lamps surmounted by a group of arc lamps and a powerful search-light. There is to be a cyclists' parade, the machines to be lighted by electricity. There will also be a banquet, at which Lord Kelvin is announced to deliver an address.

Lightning Discloses a Mineral Spring.—During the prevalence recently of a thunderstorm in the neighbourhood of Seis, in the Tyrol, the lightning struck a heap of old wood which was piled on a rock, splitting the latter and setting fire to the former. When the flames had been extinguished, it was noticed that a stream of water flowed from amidst the rubbish. Further examination showed that the stream proceeded from the lightning-created cleft in the rock, and chemical analysis demonstrated that the water was impregnated with iron and magnesium, in the form of sulphates.

Willans Memorial Fund.—We are asked to mention that the subscription lists for this fund will be closed on November 1, so that any engineers or others who intend to send in subscriptions and have not done so should do so at once. Mr. Alexander Siemens, 12, Queen Anne's-gate, Westminster, is the treasurer of the committee. It may be remembered that the proposal is to establish a fund in connection with the Institution of Mechanical and Electrical Engineers from the interest of which a premium might be awarded for papers relating to the subjects which the late Mr. Willans made so peculiarly his own.

Water Power in India.—The committee of experts appointed to enquire into the question of utilising the water power shortly to be available at Peniyar have sent in a report to the Secretary of State. There is believed to be no doubt as to the practicability of turning this water power to good account. It is submitted that the first step that should be taken is the construction of a light electric railway from the foot of the hills where the power is to be obtained, to some convenient spot on the existing railway system of Southern India. By this means the current could be distributed for the lighting of towns, etc.

University College, London.—The new engineering and electrical laboratories in this college are now ready for the reception of students. This new wing of the college will afford greatly increased facilities for teaching mechanical, civil, and electrical engineering. Complete laboratory and lecture courses in these subjects are given under the direction of Prof. T. Hudson Beare, Prof. J. A. Fleming, and Prof. L. F. Vernon-Harcourt. In addition to these engineering laboratories, new physical laboratories have been erected for Prof. G. Carey Foster, and the whole of the new buildings are completed for the session which is now commencing.

Hardening Aluminium.—The hardness which aluminium is said to lack can, according to a new process, be imparted to it by the addition of chromium. Of course certain precautions have to be taken to alloy the two metals, owing to the difference in their fusing points. If electrolysis is employed for this purpose, one or another of the known methods can be used, and the alumina, salts of alumina, cryolite, etc., treated direct with a determined quantity of granulated chromium or chromium in any other suitable condition, or with the salts or oxides of chromium. Finally, an ingot of chrome-aluminium is obtained, which can subsequently be treated and transformed by known methods. This method, it is believed, renders the aluminium as hard as chrome-steel.

Primary Battery.—A primary battery has been devised by Mr. H. C. W. Emery, in which the cells are formed in the shape of a ship's rudder, the elements being suspended vertically from the mouth, which is of small area as compared with the lower part of the cell. The elements consist of zincs and carbons, and when the battery is in its normal position, they are immersed in the electrolyte, which is a solution of chromic acid. In this position the battery is in working order, but when it is required to stop its action it is laid on its front, the cells and the elements thus assuming a horizontal position. The quantity of the depolarising solution is so regulated that when in this position the elements are high and dry above the solution, which lies in the enlarged part of the cells, and the generation of the current ceases.

Honours.—The American Electro-therapeutic Association, having widened its constitution so as to admit electrical experts, has just elected as fellows the following gentlemen: A. E. Kennelly, chief electrician of the Edison Laboratory, N.J.; J. J. Carty, vice-president N.Y. Electric Society; Prof. E. J. Houston, Philadelphia; H. Newman Laurence, M.I.E.E., London, Eng.; and Mr. J. Jenks, electrical engineer, N.Y. As this association is a select body of medical men, many of whom stand high in their profession, the admission as fellows of electrical experts who are not medical men is a significant step in scientific co-operation. We note with pleasure that Mr. Newman Laurence is among those thus honoured, and that so important a body has recognised the thoroughness and honesty of his work in matters relating to electricity and the human body.

Not Idle Tales.—Prof. Oliver Lodge, in the course of his inaugural address on "The Advantages of Indirection," delivered on the 29th ult. on the occasion of the annual distribution of prizes at the Liverpool School of Science, Technology, and Art, said it was true that all could not be leaders, "but unless a youth is ambitious he will achieve nothing. There is plenty of room to spread yourself: make

yourself a good base or you will never build high. You are going to aim high: by all means do so, but don't erect a slender top-heavy column on the surface. The higher you intend to build the broader and deeper must you lay your foundations. You who wish to become skilled artisans, do not imagine that heat, light and sound, magnetism and electricity, chemistry and mechanics, are idle tales. If you have a chance of learning these things, learn them; you can hardly overestimate the value of an acquaintance with scientific principles."

An Electric Tug-of-War.—The anniversary of the opening of the Manchester and Liverpool Railway—which took place, it will be remembered, on September 15, 1830—was celebrated by the railroad interests of America (no unimportant section of the industrial world) in the shape of a "railroad day" at the Chicago World's Fair. A great number of railway men, both Americans and foreigners, assembled together, and were treated to some addresses from prominent railroaders on topics of common interest; subsequently proceeding to an inspection of the railway and kindred exhibits in the Transportation Building. One special feature of the day's proceedings which caused particular interest to the onlookers was a tug-of-war between a steam locomotive employed for shunting purposes on the Baltimore and Ohio Railroad, and the electric locomotive exhibited by the General Electric Company, some details of which, accompanied by illustrations, were recently given in our pages (see the *Electrical Engineer*, July 28, 1893). The result of the tug was a defeat for the electric locomotive.

Chicago Exhibition.—In the course of a lengthy article in the *Times* of yesterday, a correspondent at Chicago says in regard to the Machinery Building: "The American tariff interferes with the sale of machinery, electrical supplies, and the transportation display, but manufacturers have generously exhibited in spite of this obstacle, and they generally announce the sale of patent rights for America. There are three lines of shafting in the machinery section, one being driven by a 350-h.p. horizontal compound Galloway engine. The other two lines are driven by two Willans and Robinson single-acting central-valve engines, respectively of 360 h.p. and 165 h.p." The same correspondent states that there is not much British competition in the Electricity Building, only five exhibitors appearing in this enormous display. The British Government makes an extensive postal-telegraphic display, which is one of the best exhibits in the building; the General Electric Company, of London, shows electrical apparatus and arrangements for lighting; the Epstein Electric Accumulator Company shows batteries, etc.; and J. G. Lorrain has various electrical appliances.

Cables, Wires, and Batteries.—A revised price list of electric light cables and wires has been issued by the India Rubber, Gutta Percha, and Telegraph Works Company, Limited. The list is divided into two parts; the first referring to vulcanised and the second to non-vulcanised rubber cables. In the first part three series of cables have been arranged suitable for installation wiring where the E.M.F. used is only moderate. Then come cables for underground work and the concentric series, made for pressures up to 2,500 volts. During the process of manufacture all the vulcanised cables, wires, etc., are subjected to a temperature considerably over 200deg. F., and they can therefore be relied upon to work efficiently even at such high temperature. They are, moreover, tested in water with a battery giving an E.M.F. of at least 500 volts, and the tests for insulation taken after one minute's electrification, and after they have been immersed at 60deg. F. for at least 24 hours. This high pressure and long immersion are calculated to break down any faults that might exist in the cables. The same company have issued a list of the Silvertown dynamos, made in sizes giving outputs of from 1,500 to 48,000 watts, and a list of galvanic batteries for telegraphic, signalling, and electric bell work, for testing purposes and for torpedo firing and for blasting operations.

Currents between Gas and Water Pipes.—Some time ago attention was drawn in the *Genie Civil* to the difference of potential between gas and water pipes, and now Dr. S. Kalischer, in the *Elektrotechnische Zeitschrift* of the 22nd September, refers to experiments made in this direction in the physical-room of the Agricultural High School. The object of the investigations was to determine whether in the path of the current any relation was found to the magnetism of the earth and to meteorological data. No less than 2,000 observations were made by Dr. Kalischer in conjunction with Dr. Less. The inconstancy of the current rendered the making of the measurements very difficult, but Dr. Kalischer was enabled to make a number of measurements of the E.M.F. on the compensation method. A Daniell cell was used as the compensating element, and the ascertained maximum current obtained with this cell amounted to ·0024 ampere, and the minimum to 0·0004 ampere. The greatest internal resistance of the "earth battery," as the combination of the pipes with the earth is termed by the author, came to ·5871 ohm and the smallest to ·0310 ohm. As far as the direction of the current is concerned, the water-pipe plays the part of zinc in a galvanic cell: the current passes from the water-main through the earth to the gas-main. A permanent diminution or increase in the current was not noticed. The author concludes by stating that it will perhaps be possible to ascertain further information concerning the nature of these currents by the use of registering apparatus.

Electric Distribution of Time.—Mons. H. Campiche, of Geneva, who supplies all the clocks for the Egyptian Government railways, post office, and telegraph departments, has devised an extremely simple type of electric regulator or master clock, from which may be operated a number of dials throughout a circuit for the purpose of showing time synchronously with the regulator. The appliance consists mainly of a seconds pendulum, near the top of which is fixed a horizontal spring actuating a ratchet wheel with 30 teeth. The wheel thus makes one revolution per minute: on its axis a lever is carried, with a contact at the end. As the wheel revolves, an electrical contact is thus made once in each minute, the current passing momentarily through the entire circuit, and operating all the receiver mechanisms with ordinary electromagnet and ratchet devices. There is also inserted in the circuit an electromagnet fixed to the pendulum case, with a balanced pivoted armature. The latter is raised at every vibration of the pendulum by an arm fixed to the latter through the intervention of a spring; at the moment when contact is made and current passed through the circuit, this electromagnet is, of course, energised similarly to all those in the receiver mechanisms, the armature is attracted downwards so as to give a blow to the pendulum arm and thus keep up the oscillation. The force of this blow is regulated and kept in form by means of the spring between the arm and the pendulum itself. Every minute, therefore, a fresh impulse is given to the pendulum, and the winding up of a clock train wholly avoided. A few Leclanché cells of No. 2 size are sufficient to supply the necessary power for operating the magnets.

Electrical Engineering in Queensland.—A correspondent informs us that the central station of the Rockhampton Gas and Coke Company, Limited, which

is the only gas company in Queensland that supplies both electric light and gas, was erected under an Act granted in November, 1889. The plant at the station, which was started in September of last year, consists of two 120-h.p. Roots boilers by Conrad Knap and Co., Lincoln; a 100-h p. indicated horizontal engine, by Davey, Paxman, and Co.; and a 6½in. by 6in. Westinghouse engine, a 280-ampere 110-volt Hookham patent dynamo with constant-lead brush gear, hand-regulated by resistance in field-magnet circuit, and an A. Mordey-Victoria alternator, the whole plant being thus capable at present of supplying 2,000 8-c.p. lamps, of which 914 are in use outside the works and 1,700 on order. The Fitzroy Bridge is lighted by alternate-current arcs, and the cathedral by eight arcs and 20 incandescents. The whole of the mains are laid underground on the Callender system, and the current is charged by meter or by contract as the case demands. Hookham's meters are used. The supply is from 4 p.m. to 7 a.m., and is maintained well. The company are also undertakers of isolated installations, their largest at the present time being the re-establishment of the electric light plant at the Mount Morgan Gold Mining Company's Works, Mount Morgan. This new plant consists of 60 light and 25-light 10-ampere Kapp dynamos, with Brockie-Pell arc lamps in series, and a Crompton 100-light incandescent dynamo. The circuits are over eight miles in length, and are carried overhead on poles and Pell's patent fluid insulators. The engine is a 20in. coupled high-pressure, by Fowler, of Leeds. There are two Paxman Lancashire boilers. Over 50 arcs and 30 series Bernstein lamps are in use on the high-tension circuits, and 85 incandescents of 16 c.p. on the low-tension. These two installations are the largest in Queensland, and have been entirely planned out and erected under the immediate superintendence of Mr. A. E. Neal, the electrical engineer to the gas and coke company.

Maximum Efficiency of Arc Lamps with Constant Watts.—In a paper on this subject presented to the recent Electrical Congress in Chicago, Prof. H. S. Carhart, of Ann., stated that it was of interest to determine, in connection with the proposal to define a 2,000-c.p. arc light in terms of the watts expended on it, whether the illumination is independent of the current as a variable. He said that if a 2,000-c.p. lamp shall be defined as one requiring 450 watts for its maintenance, shall the current be 10 amperes and the potential difference of the arc 45 volts, or will a smaller current and a higher voltage give higher illumination? The experiments to which the author referred were conducted by three of his pupils, and they were confined to the circuit of a constant-current dynamo with closed-coil armature, and to soft plain carbons $\frac{7}{16}$in. diameter. The method employed was as follows: With any constant current within limits a series of measurements of candle-power was made by changing the length of the arc, and hence its potential difference. A curve was then plotted with candle-power and volts as co-ordinates. Fifteen such curves were drawn for currents ranging between 6·75 and 10·75 amperes. Then any number of watts was chosen, say 450, and this was divided in succession by the several currents used in obtaining data for the 15 curves, or by so many of them as came within practical limits. With the potential differences obtained in this manner, and the corresponding candle-powers read off from the several curves, another curve was constructed, with candle-power and volts as co-ordinates, and with the watts constant. Such curves showed a maximum point corresponding to the volts at which the lamp gives the greatest candle-power. The measurements were all made in the photometric room with a 32-c.p incandescent lamp as a standard of comparison. The author had plotted only four of the 15 curves composing the series. In the four cases, with currents of 7·3, 7·9, 8·7, and 10·75 amperes respectively, a maximum of only a little over 1,100 candles was obtained. Two curves derived from all the data, and with constants of 450 and 500 watts respectively, both showed a pretty well defined maximum at 54 and 55 volts respectively. Hence for a lamp of 450 watts the current should be about 8·4 amperes with the above-mentioned carbons. The candle-power was then 900. At 10 amperes and 45 volts the curve showed the surprising fact that the candle-power was only 450. With 500 watts the current rises to about nine amperes and the voltage to 55. The author does not attach great importance to these particular figures, but the series of experiments shows a very large variation of candle-power, current and potential difference varying inversely, their product or the watts remaining constant.

A Powerful Lighthouse Light.—What is regarded as the most powerful lighthouse light in the world is now being fitted up at the Cap de la Hève lighthouse. The old Alliance magnetos have been replaced by two direct-current dynamos, giving from 25 to 100 amperes at 70 volts, and two de Méritens alternating magnetos, yielding the same intensity at from 40 to 45 volts. The current will be used in Serrin regulating lamps having cylindrical carbons. The optical apparatus devised by M. Bourdelles in place of the old fixed lights, produces a flashing light every five seconds. It possesses this peculiarity over the old type of apparatus—namely, that the number of lenticular panels, which in lights of the first order varies from eight to sixteen, has been reduced to four. The difficulty of revolving the panels at the necessary rapidity so as to produce the flashes at sufficiently regular intervals has hitherto prevented this improvement being carried out, but this disadvantage has now been overcome in a most ingenious manner. A float placed in a mercury bath supports the optical panels, the weight of which is considerable, and which is equilibrated by the "push" of the liquid. The resistance to be overcome in the rotary movement is thus reduced to the friction on the mercury. By means of this arrangement, the new light at the Cap de la Hève will be able to make a complete revolution every 20 seconds, whereas with the ordinary lighthouses of the first order at least four minutes are required to effect this operation. The new apparatus has been constructed by Messrs. Sautter-Harlé and Co., and the optical part is made of a special glass composition from the works of Saint-Gobain. The old square lantern has been removed and a circular one substituted. The following table, giving the luminous powers and the range of the light in fine weather for the different systems used at la Hève, shows the great progress made:

Apparatus.	C.P.	Distance visible in nautical miles.
Oil lamps with reflectors	7,600	41
Oil lamps with fixed lenticular apparatus	19,000	49½
Electric arc lights with fixed lenticular apparatus	25,000	57½
Electric arc lights with flashing lenticular apparatus	24,000,000	130½

The most recent electric lighthouses—Ouessant, Belle-Isle and Barfleur—have a power of 5,700,000 candles, and are visible a distance of 62 miles. The new lighthouse light at the Cap de la Hève will, however, be more powerful, attaining something like 30,000,000 c.p. to 40,000,000 c.p., and its geographical range is about 23 miles.

Lighting of the Gardening and Forestry Exhibition.—The method of lighting this exhibition, now being held at Earl's Court, S.W., is of a most varied character. It comprises high tension series arc lighting, low tension parallel arc lighting, alternate current arc lighting with transformers, high-tension alternate-current incandescent lighting with transformers, direct-current electric motors, and alternate-current electric motors. The steam plant consists of four Davey-Paxman steel loco. boilers working at a pressure of 120lb., a compound horizontal fixed engine of 210 i.h.p., one of 120 i.h.p., and a coupled compound engine of the girder type capable of working up to 120 i.h.p. These, which are also by the same makers, are arranged to drive respectively on to three independent countershafts working in line with couplings ready for connection in event of any one engine being stopped. The dynamos are driven by means of belts from this line of countershafting. The dynamos comprise eight Brush arc light machines, each capable of running 35 10-ampere lamps in series, two of which are reserve, two low-pressure direct current Victoria dynamos used for the large projector arc lamps in the arena section, one 100-kilowatt Mordey alternator, and one 37-kilowatt Mordey alternator. The larger of the two alternators, working at 2,000 volts, maintains 1,000 incandescent lamps throughout the buildings and grounds and the arc lamp for the luminous fountain, these all being worked in groups from small transformer sub-stations. The 37-kilowatt alternator supplies the current for the lighthouse only. In addition to the above plant, a complete set of gas-engine, dynamo, and accumulators is in operation to maintain a continuous light for an experiment in plant culture under electric light, daylight being completely excluded, and the accumulators supplying the light during the night. There are 210 Brockie-Pell arc lamps arranged throughout the building and grounds. An interesting feature of the outdoor lighting is a small illuminated fountain in the Western Gardens. This has been specially designed by Mr. G. C. Fricker, who has carried out the lighting at the exhibition. It is a new departure in colour-changing fountains, being perfectly automatic in action and working most successfully. The light from a powerful arc is thrown horizontally from some 15 yards distance in parallel coloured beams on to a mirror at 45deg., from which it is reflected vertically through a glass plate under the jet. There are five distinct colours which succeed each other at an interval of one minute by means of a simple relay and electromagnetic gear. The effect is pretty, and it is probable that the next application of this device will be on a considerably larger scale. The lighthouse in the Central Gardens carries one of the most powerful arcs which have ever been used. The current supplied is 250 amperes, and the light is refracted by a powerful set of revolving lenses into 12 separate beams, each of which, as it slowly sweeps the horizon, can be seen in dazzling brilliancy for some miles around London. The lighting of Captain Boyton's World's Water Show constitutes a large section of the installation. There are on the roof around the arena 10 projector lamps, each of about 10,000 c.p to 15,000 c.p., and three search lamps of some 20,000 c.p. to 30,000 c.p. each. In addition to these there are 20 arc lamps of 2,000 c.p., and about 100 incandescent lamps scattered over the ground. As a mark of the appreciation in which Mr. Fricker's services have been held, a special honorary medal has been awarded to him for the electric lighting of the exhibition.

Refuse Destructors.—A paper on "The Disposal of Refuse" was read by Mr. Wm. Warner, A.M.I.C.E., before the British Association. The author gave some figures concerning the amount of refuse dealt with per cell in different towns and the horse-power obtained from the destructors. As the subject is of considerable importance, we produce the author's statements as follow: "From a report of the committee at Oldham, Horsfall's destructor deals with 5·5 tons per cell, and at Leeds, with Horsfall's steam-jets and Hewson's improvements, their destructor deals with 5·5 tons per cell in 24 hours. The cost of burning refuse at these towns, exclusive of interest on capital, is: Batley, 7½d. per ton; Blackburn, 10d.; Bradford, 11¾d.; in Fryer's destructors, 9¾d. per ton, the cost at Hornsey is 9d.; and at Newcastle, 8d., or equal to 8½d. per ton in Warner's Perfectus destructor. At Oldham the cost is given at 1s. 1d. per ton in Horsfall's destructor. The horse-power given at Batley is 5, at Blackburn 5 6, Bury 4, Bradford and Leeds about 4 per cell, which is equal to about 4·5 h.p. generated from 5cwt of refuse, or about 125lb. per horse power, and 6·25lb. to 1lb. of water evaporated, giving a comparison of about one forty-second the value of coal when burnt in Fryer's destructor at the above towns. The horse power at Hornsey is about the same in the "Perfectus" destructor. At Oldham the horse-power is given at 50 for six cells, equal to 8 3 per cell, or about 46lb. of refuse per horse-power, and 2·3lb. to 1lb. of water. It is, however, difficult to reconcile these figures, as practically the same furnaces, with equal steam generating appliances, give less than half that power at Leeds and Bradford. It will be seen from these figures we cannot look forward to a large amount of power for electric lighting, and it is even questionable whether the power generated could be usefully adopted for that purpose. Take a town like Nottingham, and suppose its refuse to have the average steam-producing qualities, we should get about 300 h p. for an expenditure in labour of nearly £17 per day, equal to over £5,000 per annum. With coal, the cost for labour would be only £150 per annum, and the cost of coal for fuel would be under £1,500; therefore, taking the refuse to cost nothing for delivery at a destructor works conveniently situated for producing electricity, the actual loss would amount to no less than £3,350 per annum over coal fuel, and if we take into consideration the cost for repairs and interest on capital, this loss would be greatly increased. Looking these facts in the face, electric light produced by burning refuse can only show economical results in very exceptional cases, and authorities should well weigh the matter over before launching into a scheme of that kind. I have estimated the cost of burning at 10d per ton, but if the treament should cost 1s., the increased loss would be £1,245 per annum, making a total loss of £4,590 per annum. Taking the comparison of burning refuse in different kinds of destructors, these figures should be taken carefully into consideration, as 1d. per ton more in the cost of burning means over £600 per annum at a town the size of Nottingham. I have dealt with the burning of refuse from a financial point of view, and now will review them as a sanitary improvement. On reference to the cost at various towns per ton of refuse burnt, Blackburn is 2¾d. per ton; Bradford, 5d.; Burslem, nothing; Ealing, 3¾d; Eastbourne, 1½d.; Hampstead, nothing: Liverpool, 2½d.; Longton, nothing. showing an average of 1¾d. per ton. It will be seen that the cost of treatment is considerably increased, and where steam power is not used, this will tell against the working expenses; but where the power is useful either for electric light, sewage pumping, or other purposes, the amount spent in coke is returned in useful work, and therefore the apparatus does two things—i.e., it pays its own expenses for fuel in the form of steam, and at the same time destroys the offensive gases produced in the destruction of house refuse."

TRANSMISSION OF POWER.*

BY R. S. ALLAN.

The transmission of power is a subject of the utmost importance to the engineer, as I may say his reputation chiefly depends upon the results obtained by his mechanical contrivances. In these days when competition between manufacturers is so keen, and the prices accordingly so much cut down, economical machinery is essential, so that it becomes the chief aim of the engineer to design his motors and transporters with the greatest possible working efficiency. The transmission of power may conveniently be divided into two primary classes—viz. :

1. Short-distance transmission.
2. Long-distance transmission.

Various methods are adopted in each case as are thought most efficient and economical under the working conditions.

Short-Distance Transmission may be obtained by the following means : (1) Direct driving from motor shaft ; (2) friction gearing ; (3) toothed gearing ; (4) screw gearing. Direct driving consists in prolonging the main shaft of motor, and obtaining the necessary power from it without the use of countershafting or gearing. The most common adoption of this method is in the marine engine, where the power transmitted is sometimes enormous, the most notable examples being the twin Cunarders "Campania" and "Lucania," each of whose shafts will transmit no less than 15,000 i.h.p. when running at about 80 revolutions per minute. Such a shaft would be about 24in. in diameter.

Friction Gearing is those forms in which the power is transmitted solely by the adhesion or reluctance of the driving agent to slip. The various devices in use at the present day are belting, ropes, and friction wheels. Driving by belting consists in straining flat belts, or bands, over cylindrical pulleys, or drums, which are keyed on the shafts to be actuated. Various substances are used for belting, such as leather, waterproofed cotton, rubber, and canvas, woven hair, etc., according to the class of machinery under operation. Leather is the substance most frequently used, and when properly tanned and stretched is the most durable, especially when running between setters for intermittent motion, as in workshops ; the edges of belts made from other materials fraying much sooner under this action. Leather is generally used as a flat belt of varying width and thickness, according to the power required, and to prevent slipping off runs on a slightly rounded pulley. Messrs. Tullis, of Glasgow, have introduced what is known as the chain belt, consisting of short links of leather connected in rows by wire pins passing through each series. This belt is very flexible, easily shortened, and the makers claim that when it is concaved to suit the convexity of the pulley it can transmit 25 per cent. more power than an ordinary flat belt of the same width. I think that this belt would be specially suited for high speeds, as the air current generated and drawn in by centrifugal force between the belt and pulley would readily escape between the links. This centrifugal action can be counteracted with ordinary belting by boring holes at short intervals, but this of course is at the strength of the belt. Messrs. Tullis have also introduced the narrow belts with V projections riveted on the lower side, and working under the same conditions as ropes to be described further on. Leather belts have been made up to 75in. in width, Messrs. Sampson, of Manchester, having recently placed a belt of this width to transmit about 700 i.h.p. for a woollen manufacturing firm near Brussels. The composition belts are preferable to leather under some circumstances, as, *e.g.*, in damp places waterproofed cotton or vulcanised indiarubber would be employed. Cotton has a breaking strength of about 4,500lb. per square inch of section, while leather and rubber give way at about 3,000lb., but the working tension is usually far below this, or from 300lb. to 650lb. per square inch of section.

Friction Wheels are sometimes used where a quick disconnection is desired, and where the power to be transmitted is small and no great uniformity required. The wheels are generally of the plain cylinder or wedge types. In the former, the working surfaces may be iron, but a coating of wood or leather greatly increases the adhesion. In the latter type, the working surfaces are V grooves with an angle of about 30deg., turned true from solid cast. This style lessens the wear by increasing the working surfaces.

Rope Gearing.—This form of drive is now becoming extensively used in place of leather belting, especially for main drives. The ropes are made of hemp or cotton, the latter material being the most economical. They are circular in section, consisting of three or four strands sometimes twisted round a soft central core, thus giving the rope flexibility and preventing undue hardness. The main drive with rope gearing is taken from a large pulley keyed on the shaft, and having V-grooves truly turned on its circumference. The grooves have their sides inclined to include 45deg., and are shaped so that the ropes do not bottom, but are wedged in, the adhesive force being chiefly derived from the weight of the ropes themselves. The breaking strength of hemp varies from 9,000lb. to 12,000lb. per square inch of section, while cotton is about half of this. The power transmitted depends on the speed and tension, which are generally about 200lb. to 350lb. for cotton, and up to 900lb. per square inch for hemp, with a velocity of from three to six thousand feet per minute. The size of ropes in practice range up to 2½in. in diameter. Each rope requires a groove for itself, and as many as 70 ropes have been run from one pulley, transmitting about 4,000 h.p. Several drives at different elevations would be taken from such a pulley ; and several ropes used for each drive. In addition to hemp and cotton, ropes made of leather, of square and spirally twisted sections, are sometimes used for light transmissions, the groove for the former being shaped about 70deg. Some makers profess to cast the grooves smooth enough for working, but they cannot be too smooth, and are better turned, those sizes below ¾in. being generally cut from the solid cast. For the smaller sizes of pulleys the grooves when cast in may be made tolerably smooth by means of a rapidly-revolving emery disc introduced into groove as it slowly revolves in the lathe.

Toothed Gearing.—When the power to be transmitted is large, and where a constant or relative speed is required, friction rollers would slip, and to overcome this defect projections are cast on the face of the driving wheel working into interstices on the follower ; and this constitutes what is termed toothed gearing. The form of this projection or tooth, as it is called, should be such as to give the same uniform smooth motion as with plain rollers. The curves which are found to fulfil these conditions best are the involute and the epicycloid, and in practice these have been adopted. The involute is most suitable for some classes of machinery in which the pitch circles of the gear do not always coincide, as in crushing and rolling plant ; but the epicycloid is almost universally adopted in general engineering. The exact contour or curves of the tooth is obtained by rolling a circle, the diameter of which is generally from one and a half to three times the pitch on the pitch circle of wheel or pinion. This gives an epicycloidal curve for the point of the tooth, and a hypocycloidal for the flank, when the wheel and pinion work externally, but when internally the curves of the wheel are reversed, the hypocycloidal becoming the point, and the epicycloidal the flank. The rolling-circle method has the disadvantage that only a wheel and pinion specially made for each other will work together. This objection can be overcome by using the odontograph invented by Willis, when all teeth, if of the same pitch, will work harmoniously. The teeth of gear wheels when first introduced were cut by hand ; later on this gave place to casting from a full-sized pattern. These wooden patterns, owing to shrinkage induced by repeated contact with the damp mould, sometimes become distorted, and uneven teeth is the result, gear so produced tending to knock. A marked improvement on this method was the introduction of the moulding machine, which by gear wheels can divide the wheel circle into the exact number of parts there are teeth. For this method

* This paper is the prize essay of the Aberdeen Mechanical Society. The length of essay was restricted to what could be read in 15 minutes.

only the pattern for one tooth and a core-box for one arm is required, or, better still, a set of arms if a suitable pattern can be found among the stock. All teeth moulded from the above methods, however, require a good amount of clearance, which is very objectionable and detrimental to gearing liable to sudden shocks. Modern science and improvement, however, has resulted in the wheel rim being cast solid, and teeth cut by milling tools turned to the exact shape of tooth section. Teeth made in this way are very accurate, and to all appearance approach as near as possible to perfection. They can be run at a high speed, and having no clearance are strong, and the whole face is ensured of contact, thus distributing the driving force: and these are results and advantages which cannot be obtained with any great degree of accuracy in moulded teeth. The various forms of wheels are spur, bevel, mortice, and helical. Spur wheels are used to connect two shafts running parallel. Bevels are the frusta of cones, the apices of which would meet in the intersection of the shaft centre lines. When of the same size they are called "mitre wheels." Bevels generally run at right angle, but when at any other they are called "skew bevels." Mortice or cog wheels are employed when the machinery is liable to shock, and where a quick smooth motion is desired. They consist of wooden teeth, generally of hornbeam or beech, driven into rectangular holes cored in wheel rim, and are fixed at the back by iron pins and wooden wedges. Helical wheels have their teeth inclined generally at 55deg. across the face of rim. The teeth are just part of a screw generated on surface of rim, and they may either be single or double helical. The former is sometimes objectionable on account of end thrust, but this defect is entirely overcome by the double helical which, when cast with all their teeth intersecting in the centre line plane, give a very steady motion each side of the tooth supporting the other. Helical is the strongest form of tooth we have, being about 20 per cent. stronger than the ordinary spur, while mortice is about 25 per cent. weaker. Other forms of toothed gearing are in use, such as sprocket and pocket wheels. Sprocket wheels and chains are used where a relative speed is required at a distance too great for wheel contact. The teeth are set radially on the rim of wheel, and work into pitched chains, which are now made up to large sizes. The links in the larger sizes are made of cast steel or malleable cast iron, while the smaller sizes are made from mild steel These chains are largely used in elevating and conveying machinery, as the links form a ready means of attaching buckets and pushboards. Pocket wheels are generally made to suit the common forms of linked chains, the spaces for the links being hollowed out on the wheel rim, giving the name pocket. This style is chiefly used in hoisting machinery.

Screw Gearing is only used for secondary motions, such as in machine tools, etc. The screw threads usually employed for this purpose are either square or buttress, and work in conjunction with their nuts, transmitting the power by end pressure. The best example of the screw is for propelling steamships, the nut in this case being the fluid water. The endless screw and worm is another application, and, although most wasteful of power, is found very convenient in cases where the driving is wanted non reciprocal, as when the inclination of the thread exceeds a certain amount the worm alone can act as the driving agent. The best example of these devices that I know of in Aberdeen is at the shearpoles, where the worm and wheel are used for the hoisting motion, the screw and nut for the derricking.

Long-Distance Transmission is now chiefly employed in connection with the centralisation of power—*i.e.*, in places where a great amount of power is required spread over a large area. It is found better to generate the power at a central station, and transmit it in quantities to suit the consumers, thus obviating the necessity of each small consumer having a generating plant of his own. The methods in use at the present time are: (1) Water under pressure. (2) Wire ropes. (3) Compressed air. (4) Electricity.

Water Under Pressure.—When water can be stored at a high level it possesses latent power by virtue of its weight, this potential energy being proportional to its height. This method was first introduced by Armstrong on the quays at Newcastle, where the head was obtained by pumping the water into tanks high enough to give the working pressure. When higher pressures came into use the height of those tanks became inconveniently great, and this led to Armstrong bringing out his hydraulic accumulator, the adoption of which marked a new era in hydraulic transmission, and to which this system owes its success. The hydraulic accumulator is the opposite of the hydraulic press, and consists of a cast steel or iron cylinder fitted with a ram kept tight by leather packing, and loaded to give the requisite pressure per square inch. A steam-engine is employed to pump the water into the cylinder against this weight, the ram rising as the quantity of water increases. The rise and fall of the accumulator are automatically regulated by tappet arrangements connected either to the engine throttle or to a relief valve discharging back the overflow to the storage tank. The high-pressure water is conveyed from the accumulator by a main, from which branches lead to all the motors. This system is almost exclusively English, and is adopted in some of our largest cities, such as London, Liverpool, Birmingham, etc. The machinery actuated is chiefly of the non-rotary class, such as hoists, cranes, bridges, etc.; but when a rotary motion is desired a hydraulic engine or waterwheel may be introduced. The usual pressure in these towns is about 750lb. per square inch, at which pressure the available energy of one gallon of water is rather more than ½ h.p.

Wire Ropes.—This system is carried out on much the same principles as the rope drive. It is perhaps seen to best advantage on the Continent, where it was introduced by Hirn, and where it is extensively used, especially so in France. The ropes used are made either of steel or iron, the former material being stronger and not so liable to stretch as iron. This tendency to stretch may, however, be lessened by passing the ropes through compression rollers previous to placing them in position. Ropes for transmission are of special make, being circular in section, and generally consisting of six strands of seven wires each, wound on a central core. A more flexible rope is made consisting of six strands of 19 wires each, both wires and strands enclosing a hempen core. The former class of rope is made up to 1½in. diameter, the latter up to 2¼in., and sometimes of a special quality of steel wire, having a tensile strength of 175,000lb per square inch of section. The size of pulleys for wire ropes should be as large as possible to prevent undue bending, and in practice they are about 3ft. for a ⅜in. rope, up to 22ft. for a 1½in. rope. Wire-rope pulleys differ from the cotton-rope style principally in the form of groove, the sides of which are usually inclined to include an angle of about 60deg. or more, and are dovetailed in section at the bottom for the reception of lagging to preserve the rope and increase the adhesion. Various linings have been tried, such as indiarubber, wood, cork, tarred oakum, and leather. Tarred oakum wound in the groove is very good, but leather has been found by experience to be the best. It is cut to the shape of groove section, and placed edge up through an opening in the side of rim of pulley, a closing piece of indiarubber being used. This lagging is said to last on an average of about three years. The breaking strength of iron rope is about 90,000lb. and steel about 120,000lb. per square inch of section, but the working tension is about 25,000lb. per square inch of section, when running at speeds up to 6,000ft. per minute. When the distance of transmission is great the rope is run on supporting pulleys placed at short intervals, or relays may be used where the rope, instead of running all the way, only runs from one station to the other, a double-grooved pulley being thus required in the intermediate stations.

Compressed Air.—Ordinary atmospheric air approaching very nearly to the requisites of a perfect gas is compressible, and this property has been taken advantage of by engineers to form a means for long-distance transmission of power. This is accomplished by means of the compressor, which is just a piston pump fitted with inlet and outlet valves of special design. The air is drawn

in during the in-stroke, and forced during the out-stroke through the outlet valves either into a receiver, or reservoir, or directly to the motors. The heat developed during compression in the compressor is got rid of in three ways: by cooling the air before compression, water-jacketing the compressor, or by introducing water in the form of spray into the cylinder during compression. The pressures in practice are from 50lb. to 120lb. per square inch, the latter pressure being generally got by means of the stage compressor, with intermediate cooling. The high pressure air is conveyed from the generating station to the motors by means of pipes laid similarly to those used in hydraulic installations. Paris and Birmingham have compressed-air systems, but in the latter town it has not been a decided success, owing to the form of joint adopted, a large leakage taking place in the main. In Paris they have been more successful, and by adopting a rubber joint they have reduced the leakage to about 1½ cubic feet per mile per hour—a very small loss indeed when the quantity of air passing through the pipe is considered. Hydraulic shock limits the speed of water in the mains to about 3ft. or 4ft. per second, but with compressed air a speed of 50ft. can be used with impunity. The greatest feats of engineering performed with compressed air has been the boring of the Mont Cenis and St. Gothard tunnels.

Electrical Transmission.—Power may be transmitted to a distance by converting energy in the form of mechanical work into energy in the form of the electric current. This is now generally performed by means of the dynamo-electric machine, which, to put it plainly, is just a machine for moving magnets past wires, or *vice versâ*, the connections being so arranged that the E.M.F.'s produced may generate currents. This is accomplished by fixing magnets round about (not on) an armature, which is a drum or ring carrying the conductors in which the current is developed and thence imparted to the circuit by means of collectors, or commutators. For a long time electricity was thought fit for nothing but the controllation of signals, but since the advent of dynamo-electric machinery, a different aspect has been given to the system, and it now bids fair to revolutionise the world. The chief application as yet made of electricity is for lighting purposes. In this case the current is conveyed by means of insulated copper wires, two of which are required to complete the circuit, the difference of potential between the wires giving the flow, the pressure of which is measured in volts, and the rate of passage in amperes. An important and increasing application of electricity is on the electric railway, where the current is supplied by means of a feeding conductor of special channel iron laid and supported on insulators between the rails. A passing connection is made between the conductor and the electric motor, which is generally fixed direct on the axle shaft, by this means saving intermediate gearing. Electricity is also coming to the front as a transmissive agent in connection with the utilisation of waste water power by the turbine. The best system yet completed on this basis is between Lauffen and Frankfort, a distance of 108 miles. The power is got from a turbine at Lauffen gearing into a dynamo, and the current is conveyed to Frankfort by means of three copper wires supported on oil insulators, which are carried on poles similar to those used in the telegraph. The efficiency of this system is said to be over 70 per cent., as out of 130 h.p. generated at Lauffen no less than 80 is delivered to the motors at Frankfort—truly a wonderful result. An installation far beyond anything hitherto attempted is at present being completed at Niagara Falls, in America, where facilities for generating and transmitting 450,000 h.p. are being fitted up, and representing a value in motive power of no less than 2½ millions per annum.

THE ROUTIN ELECTRICITY METER.

A French engineer, M. Routin, has devised, and is now manufacturing, a type of electric energy meter which is claimed to be more especially of a commercial and industrial form rather than possessing characteristics of value in the scientific laboratory. According to *L'Electricien*, to which we are indebted for details and illustrations, the Routin instrument belongs to the periodical or discontinuous registering meters, marking at fixed intervals of time, say, two, three, four, or even five minutes, the momentary value of electric energy passing through the circuit. It is considered that for all practical purposes the results thus obtained are, taking them all round, quite as reliable as those afforded by meters which are always in circuit and give a continuous record or registration, and probably this may be so in the average circuit, as no very sudden and excessive changes of load are thrown on and off within the time that elapses between the recording intervals.

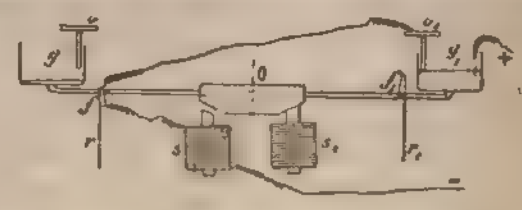


Fig. 1.

A considerable saving is thus claimed to occur in the energy required to work the meter, whilst the appliance itself may be made more strongly and with fewer parts to suffer injury or wear and tear.

After a very careful study of the requirements that are demanded from a really good and reliable electricity meter, M. Routin came to the conclusion that the following features ought to be aimed at, as being, in his mind, essential to proper working, and he has accordingly based his instrument upon them, claiming that it comes

Fig. 2.

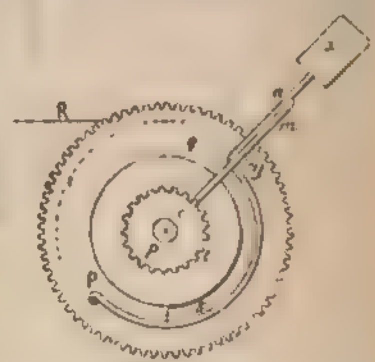


Fig. 3.

nearest to fulfilling the conditions: (1) Great exactness of readings. (2) Strong mechanical design and construction of the various parts. (3) Simplicity of same, and of the principle of working, influencing thereby the cost of manufacture. (4) Entire exclusion of all permanent magnets. (5) No springs exposed to magnetisation or other derangement. (6) No rubbing contacts, even with platinum points. (7) Calibration before sending out of the workshops, instead of in the consumer's house. (8) Great reduction in the amount of energy required to operate the meter as a registering appliance.

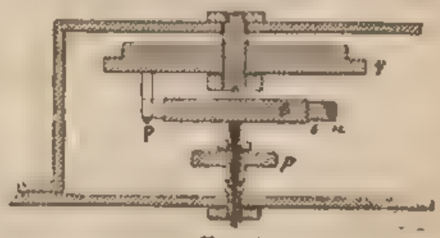


Fig. 4.

The Routin electricity meter comprises three distinct parts: (1) An electric oscillating arm, which marks exactly the interval of time desired between two successive registrations. (2) A wattmeter, giving at each fixed moment the value of the energy (E × C) passing through the circuit. (3) A train of clockwork with connecting mechanism to add up these values, thereby giving the total energy used over any required period.

The first of these parts is based upon the ancient principle of a clepsydra, or water clock, the reciprocation being effected, by means of an electric current, automatically. Fig 1 represents in diagrammatic form the outline of this oscillator, whilst Fig. 2 shows one of the details afterwards to be referred to. In Fig. 1 the oscillator appears in the shape of a fine iron tube, pivoted at O, and carrying at each end a cup, $g\ g_1$, communicating with the tube. Mercury is placed in the cups, sufficient in quantity to take an appreciable time in flowing through the pipe from one cup to the other, when the pivoted tube is tipped to one side or oscillated on its centre, O. Within the cups are two insulated screw terminals, $v\ v_1$, passing through the lids of the cups, $g\ g_1$. The tube, or pivoted arm, is maintained in position—either tipped over to the right or left—by means of two springs, $r\ r_1$, which engage with small pegs, $f\ f_1$, fastened to the arm.

Supposing that the arm has just been tilted over to the right hand side, the mercury passes along the tube and its level rises gradually in the cup g_1 until it touches the tip of the screw terminal v_1; a circuit is then closed which passes current round the electromagnet, s. A lever arm, worked by the latter (not shown in the diagram), releases the spring r_1 from the position in which it retained the arm when thrown over; the magnet, s, acts upon the iron armature fixed to the centre of the tube and pulls the latter over to the left-hand side, when the spring r catches the peg f, and maintains the arm in its tilted position. The mercury then flows from the cup g_1, along the tube to cup g, until contact is made between its level in the latter and the tip of screw v, when a corresponding circuit is made on the right-hand side, and the operations just described are similarly repeated.

The contact between the mercury surface and the screw terminal v_1 is maintained until after the spring r engages with the peg f, and in order to make sure of this, the screw terminals are set close to the inner sides of the cups, so that when the arm tips the mercury surface is inclined (as indicated in the dotted line, g_1, Fig. 1) towards the respective terminal; this gives a slightly greater depth, and a longer period of contact, than if the terminals were placed in the centres of the cups.

To prevent the sparking at the surface of the mercury, the circuit is automatically broken by rubbing contacts of platinum, as soon as the oscillation is finished and before the contact is broken between the screw and the mercury. The special arrangement of hooks on the stop-springs enable this to be done. These hooks are composed, Fig. 2, of a plate of ebonite, e, partially covered with a sheet of platinum foil, p. The latter, connected to the electromagnet, is in constant contact with the peg, c, itself connected to the screw, while the screw is not in the stop position. The circuit is thus kept closed during the time of movement, and is suddenly opened at the instant the beam reaches its position of rest. The regulation is accomplished by means of the screws, v and v_1.

Wattmeter.—The measuring part — the wattmeter — consists of a coil, B, placed near the top of the instrument (see general view, Fig. 5), of thick wire, which carries the main current; in the interior is a second coil, movable about a horizontal axis: this coil is wound with fine wire, and carries a shunt current taken across the terminals. A small counterweight exerts an inverse action to the electric couple, and keeps the fine wire coil perpendicular to the other when no current passes.

Integrating System.—Figs. 3 and 4 show the elevation and cross-section seen from above of the integrating system. This is composed of a pinion, p, gearing into a rack fixed to the oscillator. The pinion carries a finger, m, which, in rotating, meets a lever, n, at the end of which is a counter weight, x. This lever is movable on the centre, P, fixed to the wheel, q, and it is furnished with a shoe, s, which, in the movement of rotation round P, is forced against the wheel, t. This latter wheel is geared to the first wheel of the totaliser. To the wheel, q, is fixed a plug, y. The wheel is composed of two parts firmly connected, the one toothed and the other smooth; on the smooth part a spring, R, rubs, hindering its movement. The toothed part gears with a rack, C, whose upper part ends against an eccentric mounted on the axis of the wattmeter. This eccentric is cut, either empirically or as determined mathematically, so as to give the rack a movement downwards, whose amplitude is proportional to the product E × C.

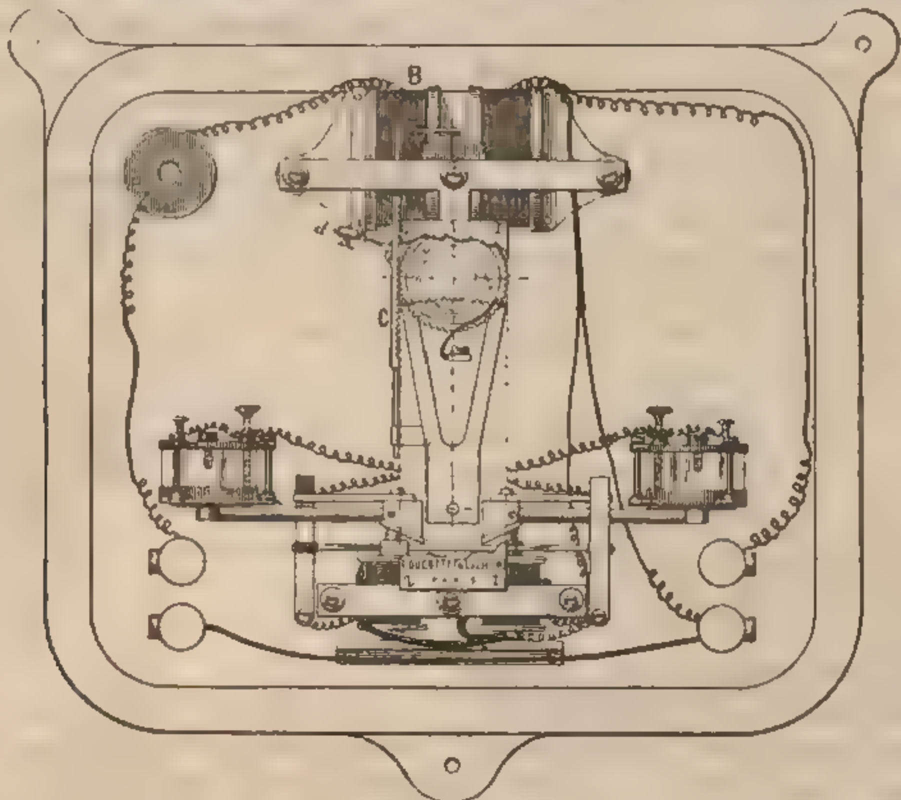


Fig. 5.

In practice, when the rack is as high as it can go, the lever, n, touches against a fixed stop, and the finger, m, draws the lever, n, by touching a spring fixed to the latter.

With regard to the mathematical determination of the curve of the eccentric, say, 90deg. + a, the angle made by the two coils, the electric couple is proportional to E C cos a, the resisting couple is proportional to sin a, whence the equation—

$$K\,E\,C \cos a = K' \sin a;$$

or,

$$E\,C = H \tan a \left(H = \frac{K'}{K}\right).$$

The equation of the curve of the eccentric in polar co-ordinates will be therefore

$$\rho = R - M \tan \alpha$$

(M being a constant, and R the maximum radius of the eccentric). To regulate the readings of the totaliser, the counterweight, x, must be shifted on the threaded stem which carries it.

The parts being thus described, the working of the apparatus, of which a general view is given in Fig. 5, will be easily understood.

During the interval of time, Θ, the pinion turns through a constant angle and comes back to its original position. When, being drawn by the ratchet, the pinion, p, turns in the direction of the hands of a watch, the finger, m, leaves the lever, n; this latter, under the action of the counterweight, x, tends to follow the movement of the finger. Under the influence of the pressure exerted by the spring, R, the lever, n, turns first around P, and the friction-shoe leaves the wheel t. But in this movement the lever meets the peg, y, and draws round the wheel q while the wheel t remains stationary. The rackwork, C, stops the movement of the wheel q when this latter has described an angle proportional to E C.

When the finger, m, turning in the reverse direction of the hands of a watch, meets the lever, n, this latter is shifted first round P, and tightens the brake, s, against the wheel t. At this time the two wheels, q and t, participate in the same movement of rotation and turn through an equal angle. The wheel q coming back to its original position, the angle described will be proportional to E C, and the totaliser will register Σ (E C Θ).

As soon as the rackwork has fallen back to its extreme position, it raises a lever, d, and puts the whole wattmeter at liberty; it fixes its momentary indication by letting the lever fall back from the beginning of its downward movement.

The system includes all the advantages enumerated at the beginning of this article; it is free of the grave defects to which the greater number of present meters are subject, notably those submitted to the competition at Paris.

The wattmeter being completely free during a time equal to $\frac{\Theta}{2}$, it can take the angle exactly corresponding to the consumption of energy. The wattmeter being braked at the moment the rackwork touches the excentric, this latter descends a space rigorously proportional to E C. The ratcheting being always accomplished with constant loss of time, the reading on the totaliser will also be absolutely exact.

The expenditure of energy required for the working of that meter is exceedingly small. Suppose $\Theta = 2$ minutes, the current will only pass into the electromagnets of the oscillator for a period equal to $\frac{1}{240}$ of the time of working. The current being about half an ampere, it will require 480 hours to consume a hectowatt, at the expense of 10c. (1d.) At an average of five hours a day, the energy consumed would come to about 40c. (4d.) a year.

Trials are being made to reduce the shunt current in the same proportion.

To apply the meter to alternate currents it is sufficient to laminate the mass of the magnet cores.

The meter is simple, strong, the regulation easy, and the fixing convenient. The meter deserves the attention of electric light companies.

INCANDESCENT LAMPS FROM THE PRIVATE CONSUMER'S STANDPOINT.

As will readily be understood from the announcements that are being made by one firm after another relative to the supply of incandescent lamps at less than one-half the current prices immediately after the expiration of the Edison-Swan Company's patents next month, the present moment is extremely opportune for bringing before our readers some figures and facts which they will do well not only to digest themselves, but also to use for the benefit of their clients—the private consumer of electricity.

The latter is an individual of many-sided character, but it may be taken as absolute that nine out of every ten persons who now enjoy the benefits of electric lighting for the interior of their premises, or who intend to do so at the earliest possible moment, are likely to feel more interest and confidence in this method of illumination, and would prove most valuable advocates of its extension, if it were shown to them that the result of free-trade in lamps means practically a large saving, not only in first cost, but also in the current used, and therefore in the total expenses.

We are shortly to be in a position to buy lamps at almost any price—from the cheap rubbish (as one is almost obliged to term it), at 1s. each, to those at 2s., with a variety of intermediate rates. The Edison-Swan Company itself—with the best possible experience and most ample resources—is asking 1s. 9d.; the Brush Company go one better, and advertise lamps from their Vienna factory at 1s. 6d.; the Zurich Incandescence Lamp Company's price is 2s., presumably because Mr. C. H. Stearn (well known as Mr. J. W. Swan's coadjutor in the early days of incandescent lamps) is giving them the advantage of his experience and energy.

In discussing, however, the economical aspects of this important development in electrical work, we shall assume as a fair price for a good reliable lamp the sum of 1s. 6d., not merely because it is the average of prices asked by the trade, but also because it allows a reasonable profit to the makers and distributors without tending too much towards the disastrous rate-cutting that usually ends in the market being flooded with absolute rubbish by unscrupulous manufacturers.

Some danger of this regrettable result is already to be feared, and both contractors and consumers cannot be too strongly warned against the short-sightedness of buying "cheap lamps and nasty."

The probability is that such lamps will neither give the candle-power claimed for them, nor will they last half as long as those made by responsible firms who have a reputation to preserve. By wasting current and necessitating constant renewals, they are indeed anything but cheap in the end.

To show consumers what real saving may be effected now that the price of lamps has dropped low enough to allow of more frequent renewals, we append some tables and other details compiled on a basis varying with the price paid for current.

TABLE A.—COST OF CURRENT, IN PENCE, PER LAMP HOUR.

		Price per Unit.			
C.P.	Watts.	5d.	6d.	7d.	8d.
16	60	·3	·36	·42	·48
16	50	·25	·3	·35	·4
16	40	·2	·24	·28	·32
8	30	·15	·18	·21	·24
8	25	·125	·15	·175	·2
8	20	·1	·12	·14	·16

Table A gives figures probably familiar already to the reader, but reproduced so that the data may be complete. It shows the cost of current in fractions of a penny per lamp hour for 8-c.p. and 16-c.p. lamps respectively, taking each three different amounts of energy for a given illumination.

Based upon this, Table B gives the total cost—*i.e.*, both of current and of renewals—over a period of 1,500 hours, which may be regarded approximately as equal to two years' lighting. The life of a 60-watt lamp is here taken at 750 hours, down to the time when it becomes too black to give the normal candle-power, even though not actually broken. Similarly the life of 50 and 40 watt lamps are assumed to be respectively 500 and 250 hours; probably all these values are well under the mark, but if so, it is to the advantage of the consumer. The price in all cases of new lamps is taken at 1s. 6d. each.

TABLE C.—APPROXIMATE TOTAL SAVING PER LAMP PER ANNUM, by substituting 40-watt lamps for 60 watt lamps; all of 16 c.p.

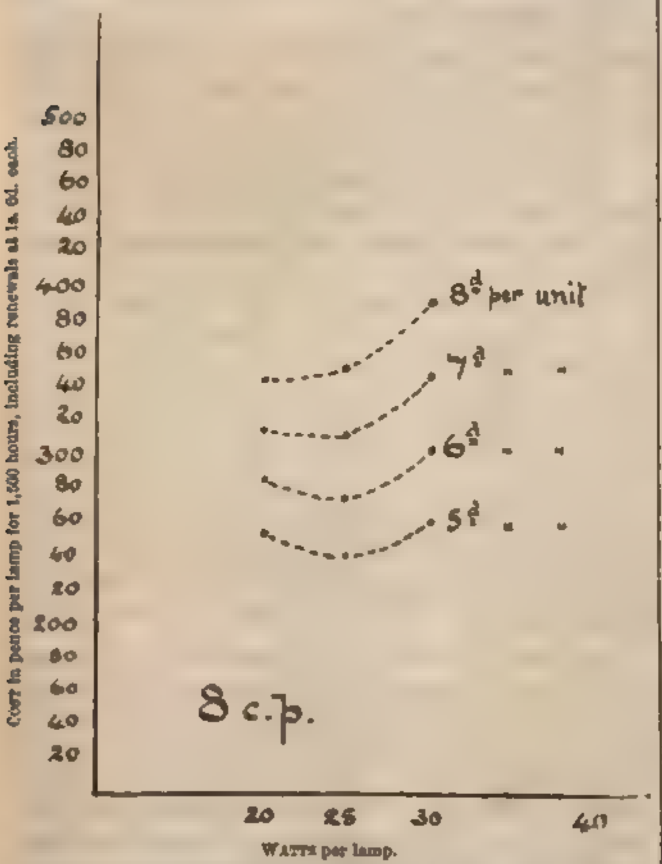
	Price per Unit.			
	5d.	6d.	7d.	8d.
Saving	3s. 3d.	4s. 6d.	5s. 9d.	7s. 0d.
Percentage	8%	9%	10%	11%

The figures of Table B show, of course, that the greatest saving is effected where current is dear—say 8d. per unit—by using 40 watt lamps. The approximate amount of total saving per lamp per annum—inclusive of renewals, in

TABLE B.—Total Cost—Current and Renewals for 1,500 Hours.

C.P.	Watts.		Price per Unit. 5d.	6d.	7d.	8d.
16	60	Current	£1 17 6	£2 5 0	£2 12 6	£3 0 0
		Renewals	0 3 0	0 3 0	0 3 0	0 3 0
			£2 0 6	£2 8 0	£2 15 6	£3 3 0
16	50	Current	1 11 3	1 17 6	2 3 9	2 10 0
		Renewals	0 4 6	0 4 6	0 4 6	0 4 6
			£1 15 9	£2 2 0	£2 8 3	£2 14 6
16	40	Current	1 5 0	1 10 0	1 15 0	2 0 0
		Renewals	0 9 0	0 9 0	0 9 0	0 9 0
			£1 14 0	£1 19 0	£2 4 0	£2 9 0
8	30	Current	0 18 9	1 2 6	1 6 3	1 10 0
		Renewals	0 3 0	0 3 0	0 3 0	0 3 0
			£1 1 9	£1 5 6	£1 9 3	£1 13 0
8	25	Current	0 15 7	0 18 9	1 1 10	1 5 0
		Renewals	0 4 6	0 4 6	0 4 6	0 4 6
			£1 0 1	£1 3 3	£1 6 4	£1 9 6
8	20	Current	0 12 6	0 15 0	0 17 6	1 0 0
		Renewals	0 9 0	0 9 0	0 9 0	0 9 0
			£1 1 6	£1 4 0	£1 6 6	£1 9 0

which the consumer naturally is interested, since he pays for them—is shown in Table C, also the percentage of saving, as between 60-watt and 40-watt lamps respectively, of 16 c.p.



In Table B, it will be noted that so far as 8-c.p. lamps are concerned the new price of lamps is still too high to allow of any material economy when current is cheap: in point of fact, the total cost of 20-watt lamps, including renewals, comes to more than that of 25-watt lamps, so that no gain is effected by the use of the former. To show this more clearly, reference may be made to the diagram, on which are marked four curves, denoting the total cost per lamp of renewals and current for 1,500 hours at different prices per unit, and for three amounts of energy required per lamp. In proportion, as the cost of current diminishes, the economy of reducing the watts per lamp is also less, and at 4d. per unit the total cost for a 20-watt lamp actually exceeds that for a 30-watt lamp.

Although, therefore, a considerable saving is effected by reducing the energy spent in lamps of 16 c.p., even at the cost of more frequent renewals, this does not wholly apply to lamps of smaller powers, and consumers may do well to bear this in mind.

The question of "overrunning" incandescent lamps is also a matter of no little importance in this connection, but requires separate treatment from a somewhat different standpoint.

THE CROSS-SECTIONAL AREAS OF STRANDED CABLES.

Assuming that a cable is made of concentric layers of wires of equal circular section, perhaps it may not be known to some that, if the copper area is given, the diameter of the core becomes greater as the number of strands is increased. Or, to take an example, a ·2 square inch core will occupy more space if made of 19 strands than if made of 7 strands.

To see this, we may suppose the space inside the insulation to be fixed, and find the ratio of the area of copper to the area of this available circular space. Now, the general term of the series 1, 7, 19, 37, ... , is $3(n^2+n)+1$, where n is the number of concentric layers round the centre strand. Hence the ratio of copper area to available area is

$$\frac{3(n^2+n)+1}{(2n+1)^2}.$$

Putting $n=0$, $n=1$, $n=2$, etc., in this expression, we find the required ratio for the different cases. The values of this ratio for the numbers of strands commonly used are as follows:

Number of strands.	Copper area / Available area
1	1
7	·778
19	·760
37	·755
61	·753
91	·752

If the number of strands is increased indefinitely the ratio becomes ·75, or $\frac{3}{4}$.

And, similarly, in three dimensions we can find that a pint of small shot will contain less lead than a pint of buck shot, provided that a number of concentric layers will fit in exactly in each case, and that the pint measure is cylindrical. If a measure of square section were used, supposing an exact fit, the amount of lead in the two cases would be the same.

W. H. Everett, B.A.

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THE BRADFORD ACCOUNTS.

The detailed accounts given elsewhere, as prepared by Mr. J. N. Shoolbred for the Bradford Corporation, contain a refutation to the absurd criticisms so often met with upon municipal action as regards electric lighting. We assume that sooner or later the accounts of other municipal electrical undertakings will be presented in like manner to these of Bradford. One of the criticisms to which we refer runs as follows: "Probably, like the Vestry of St. Pancras, the Dublin Corporation think it unnecessary to begin to allow for depreciation just yet, but this forbearance will only make matters worse in the near future." There are other equally insane criticisms, but this one will be sufficient to form a text for our present purpose. Let us candidly admit our aim to be to induce local authorities to undertake electric lighting; hence the reason for explaining what is really done, and disarming such statements. Municipalities against companies is the text. The former borrow money at, say, 3 per cent., but have to repay the capital in twenty-five or thirty years. This involves a sinking fund at the rate of little over another 3 per cent. A municipality has, therefore, no capital expenditure at the end of thirty years. A company has a capital that figures in the balance-sheet for ever. The one pays 6 per cent., and rids itself both of interest and capital; the other pays 6 per cent. and does nothing of the kind. Examine a little closely into the figures of Bradford as prepared by Mr. Shoolbred. It is evident that the plant is kept in repair and in the highest state of efficiency out of revenue. The interest on capital and the sinking fund to liquidate capital have been paid from the first. It seems to us that a sinking fund, if it means anything, means depreciation, and if you depreciate in one way it is not necessary to depreciate in another. Given, however, that there is a surplus after providing interest and sinking fund, as there is at Bradford, we have a further safety provision in the shape of a reserve fund. If the loans are paid off by instalments periodically, the interest on the loan must decrease proportionately, and the reserve rapidly increases. Of course, in the account as presented the capital has increased, but that is due to further expenditure, and has no bearing upon our argument. That further expenditure is undertaken to enable more work to be done, and thus a greater revenue to be obtained. The excess of revenue so earned is used to pay interest and provide sinking fund for the extra capital. One question might well be debated. Is the capital account extinguished rapidly enough by means of the sinking fund provided? We think yes—in fact, we should say, a little too rapidly; and no doubt if the Bradford authorities find the balance put to what we have termed the reserve fund increases rapidly, they will still further reduce the price of current, or take a certain proportion to diminish the rates. They will, in fact, have to decide whether it is best to relieve the ratepayer directly by appropriating profit, or indirectly by lowering his light and power bills. It will be seen that local authorities not only do depreciate, but they must depreciate:

they only obtain their capital on these terms; and critics who are so ignorant of municipal affairs as the one we have quoted above shows himself to be, ought to take a few lessons at some twopenny night school upon municipal economics. In the figures relating to Bradford, no doubt it will be noticed how for some time past the working expenses approach about 50 per cent. of the receipts, and again it may be surmised that the large number of units sold during the half-year ending June 30, 1893, is due to the increase of electrical energy for motive power rather than for light. We commend these figures for careful examination to every municipal authority.

LEEDS TRAMWAYS.

According to the views expressed by the Highways Committee of the Corporation, there is some hope for an extension of electric traction in Leeds. Most of our readers are acquainted with what has taken place in Leeds with regard to tramways during the past three years. Previous to that period there were tram lines to Roundhay Park, or rather to a point which ended at nowhere, leaving the would-be visitor to the park to walk the balance of the way. Some few feeble attempts were made to work this line, but unsuccessfully, and it seemed of the nature of a white elephant. Mr. Graff Baker came along, and with that energy born of contact with American soil entered into an agreement to work the Roundhay line electrically for two years. The working was successful, though the reward was perhaps less pleasing; but we have it on the best authority—that of users of the line—how great was the comfort and convenience of the service to those who lived in the district. It ought also to be said that the district was and is largely undeveloped, and that the town end of the line is inconveniently away from business centres. Two years passed and a further agreement was entered into for one year, and this third year of working expires, we believe, at the end of the present month. Meanwhile, the authorities have been considering the question of purchase of all rights not in their hands to the tramway lines, and arbitrators have practically agreed what is to be paid. The committee expect to be in possession shortly, and have agreed temporarily to work the lines themselves. Application is to be made to the Board of Trade for permission to borrow £130,000 in connection with this tramways purchase. The tramways are of three kinds—those worked by horse traction, those by steam traction, and those by electric traction. What principle of traction will ultimately be adopted is difficult to say, but the committee seem open-minded with, if we may say so, a slight bias towards electricity, and have determined to visit the Staffordshire lines in a body, though a sub-committee has been that way before. Mr. Dickenson will have thus an opportunity of explaining the various modifications he has introduced in these lines, so as to avoid some of the many evils of overhead traction. We are convinced that under proper guidance the Leeds authorities could not do better than to adopt electric traction. Preparatory to this, however, or contemporaneously therewith, they should acquire the electric lighting central station, and in the development of the electric light lay down power mains in addition to the light mains. There is no valid reason why the system adopted should not be partly overhead, partly conduit, and partly self-contained. If electrical engineers have any information of value, now is the time to influence the Leeds authorities. The decision once taken will be fatal to the use of some one or two forms of traction in the town, and it is to be hoped that electric traction will not be one of them.

REVIEWS.

The Dynamo: Its Theory, Design, and Manufacture. By C. C. Hawkins, M.A., and F. Wallis, A.I.E.E. Whittaker and Co.

This is a work of no mean ability, especially if viewed from the standpoint of a collection of valuable information. To criticise it exhaustively would mean the writing of another treatise, for opinions still differ as to the interpretation of many electrical matters. Hence, while trying to indicate the contents of this book, it will be impossible to discuss the many conclusions with which we heartily, or do more than cursorily examine some with which we do not, agree. That differences of opinion upon highly controversial matters exist does not detract one iota from the merit of a book. In the introductory chapter the authors point out the dual character of a dynamo which arises from the dual nature of electricity; not the dual nature, as ordinarily understood, of vitreous and resinous, or positive and negative, but from the dual phenomena of current and field. A glorious question for discussion would be the possibility of current without field or field without current. So long, however, as Ohm's law holds good, those who argue on the side of impossibility must have the advantage. Energy is discussed, as is the transformation of one kind of energy into another kind by means of the dynamo. Then chapters are devoted to "magnetic field" and "the magnetic circuit." With regard to the former all books assume too much of the student, and for the sake of condensation leave him with uncertain, if not incorrect, views. Such sentences as the following require amplification and explanation: "The lines of force indicated by the filings are crowded together near the poles where the force is strongest, and gradually widen out until where the force is weaker they are comparatively widely scattered." We take it that the authors believe in the "magnetic circuit"; indeed, the book is built upon this assumption, and, therefore, that lines of force must be closed curves. If that is so, the force through any given cross section of a field is absolutely and identically the same as that through any other cross section. If, however, we talk about the force through a given area of such cross section, then the sentence may be made to indicate the correct view. The density of lines per unit area is greater in the air-space near the poles than further away, and is usually greatest per unit area within the body of the magnet. The authors of text books, as a rule, are compelled to follow the teachings of the day. It is only now and again that an utterly unorthodox book is issued, and that usually at a heavy cost to the author. He airs his opinions and pays the piper. Hence, though we should prefer a closer assimilation of magnetic circuit nomenclature to conductive circuit nomenclature, and use the term resistance rather than reluctance, we cannot expect the authors to do so; nor would it be wise for them to disparage μ, although the value of μ is merely that of a coefficient which, when multiplied by the magnetic reluctance (resistance) of air, gives a product indicative of the magnetic reluctance of the substance for which that particular value is the coefficient. Permeability is a term really no more required as regards the magnetic circuit than it is in the

conductive circuit. If, however, the resistance of air is to be accepted as the standard magnetic resistance, it may be useful to tabulate magnetic resistances by the aid of a co-efficient. Still, we are advancing. It has only been during the last few years that the term "magnetic circuit" was tolerated in high scientific circles. Now we are so far advanced, we must advance further. This is how matters now stand:

Conductive Circuit.

Unit of E.M.F., the volt.

Unit of resistance, the ohm.

Unit of current, the ampere.

Magnetic Circuit.

Unit of resistance, none.

Practical comparisons are made from formula $\mu \times$ reluctance of air.

Unit of magnetomotive force, none.

Practical comparisons from $\cdot 4\ \pi$ ampere-turns.

Unit of number of lines of force, none.

Practical comparisons from a ratio, $\dfrac{\cdot 4\ \pi \text{ ampere-turns}}{\mu \times \text{resistance of air}}$.

Coming to the chapter on the production of E.M.F., have not the authors used the term "inductor," p. 41 and subsequently, in a sense not usual? The whole paragraph, too, needs amplification. It is true that you may move a conductor about in a field without getting indications upon an electrometer, but in the first place you have got to get your conductor into the field, and that cannot be done without indications, nor can it be taken out of the field without indications. This chapter will bear careful reading, as will the following chapters on magnetic pull and self-induction, especially the latter, but in the former we think the authors' definitions are not correct, yet as once defined, like "inductor," they hold to the definitions consistently, so that the reader has merely to be careful in getting the definitions. Chapter VII. treats of the classification of dynamos, pointing out that all dynamos consist of two main parts—one constituting the apparatus to obtain the field, the other the armature—and considering all the variety of designs as belonging to one of two classes: (1) those in which the "inductor" cuts the same lines twice over in opposite directions in each revolution; and (2) those in which each "inductor" when cutting lines is always cutting them in the same direction. The latter class are unipolar dynamos, the former all bi or multipolar. The general designs in the two classes are considered and the various actions explained in detail. One valuable feature throughout the book is the excellence and number of the illustrations. A mass of very interesting information about types of armatures will be found in this and the succeeding chapters, which deal respectively with "bipolar and multipolar alternators," "unipolar alternators," "open-coil armatures," and closed-coil armatures. Due credit is given to the pioneers in armature design—Pacinotti, Gramme, Siemens, Von Hefner Alteneck—and if after digesting these chapters the reader has not obtained a fair grasp of the variety of design, he never will.

(To be continued.)

THE RETURN CIRCUIT OF ELECTRIC RAILWAYS.*

BY THOS. J. M'TIGHE.

I have had the honour of being appointed a special committee to make a report upon "The Return Circuit of Electric Railways. To show you that the magnitude of the honour has been appreciated, and the gravity of its duties well weighed, I may say that during the whole interval the committee has been in session every day and night, including Sundays. I may also add that a committee so continuously controlled by the pernicious one-man power has hard work reaching sound and impartial conclusions upon the questions forming the subjects of deliberation at the sittings. One leading difficulty has been to obtain some crumbs of certainty from the confusing experience of others. At one sally of the committee, after deciding that iron rail bonds were only worthy of execration (and rust), we were told that nothing but iron is trustworthy. Another opinion, obtained the same day, and also based upon alleged long experience, was that the bonds should be copper and the ends or rivets soft iron. The heathen who gave this opinion, I am glad to say, has since come into the fold. Still another, also a man of experience, announced that rail bonds were all wrong, that the only thing to do was to lay a No. 0 supplementary copper wire and connect each rail to this by a soldered branch terminating in a copper rivet soldered to it and simply driven into the rail at any convenient point. That made harvest enough for one day. The committee went home and entered into executive session, and decided to remain in executive session indefinitely, and try to get at the question in its own way, since at the outset it got a knockdown blown for attempting to believe the doctrine *experientia docet* to be infallible.

The progress of the trolley system of electric railways has been so rapid as to become almost bewildering. A multitude of improvements had been added, the necessary result of careful thought and ingenuity of the electric engineer, and the critical study of the practical railway manager and his assistants. But this has been mostly true of the track and overhead construction and the cars and power equipment The return circuit has been rather neglected, being largely a case of "out of sight, out of mind." Originally installed on a basis evidencing immature study, and necessarily without experience, it has been left to shift for itself, or rely upon Mother Earth to open a frictionless path for the nearly exhausted pressure to get back to the power-house. Few practical investigations of efficiency have been made, and data are meagre. Yet the return circuit is in some respects quite as important a factor of the system as the overhead circuit, and a moment's thought will show this to be true. The efficiency of an electric circuit depends upon the resistance of all the parts. We carefully figure out the amount and size of overhead wire, so as to bring down the waste of energy in transmitting current to the motors, and we should be logically bound just as carefully to plan out the return circuit. There is this important difference, too, in our favour in the latter case, that while we must have all copper overhead, and consequently must struggle with the spectre of cost, when we get in the ground we have a veritable tower of refuge present in the rails, if we but choose to take proper steps to avail ourselves of their valuable help. Track rails are necessary, and they are getting better and bigger for our circuit purposes, and I believe that it will not be long before the absurd and costly supplementary wire will have joined the vast army of discarded "expedients," and with it the earth as a permanent part of the return circuit, except in some special cases.

On a wet day in moderate weather the earth is available, and to a very large extent, I believe, considering that with a 70lb. girder rail and double track we have something like 30,000 square feet of earth contact per mile of track. But we cannot rely upon this doing us the same service in long spells of dry weather. Still more, we cannot rely upon it doing any good whatever in severe winter weather. It is not uncommon in this State for frost to penetrate 3ft. in the ground, and to stay there for a whole winter. Under such circumstances the earth return must go out of our calculation. It is during severe winter weather that we want to realise our very last watt in the hard pulls we must contend with almost daily.

We are told in mechanics that the strength of a structure is measured by that of its weakest part under the most unfavourable conditions it is to meet. Similarly, in a compound electric circuit, the total resistance must depend upon the condition of highest resistance to be met with in any of its component parts. We must plan so as to have our return circuit efficient in the most prolonged summer drought, and in the most severe frosts of winter. Ground plates and pipes laid below permanent water-level are a refuge in a few favoured localities, but the same can hardly be said of plates and pipes laid in the ground whose moisture depends upon the wayward elements.

* Report read before the Street Railway Association of New York State, September 19, 1893.

I have made a large number of calculations as to what should be the total resistance per mile of the return circuit under different methods of the construction of the circuit. In making these calculations I have eliminated the conductivity of the earth, because in average winter weather the earth turns a very cold shoulder to the track. I have eliminated the conductivity of the fishplates, because I believe that under average conditions the comparatively small areas of contact surface are too much oxidised to be of much benefit. The most approved form of fishplate bears only at its upper and lower edges against the rail. The rail and plates are merely special forms of structural steel, rolled while hot, heavily oxidised at best, and usually rusted still more before being applied. Two such rolled surfaces never come into good contact throughout, and it cannot be expected. A straight-edge laid along the bearing surface of the ordinary fishplate will convince anyone who takes the trouble. Even on our magnificently constructed and continuously maintained steam trunk lines I have, on examination with my knife blade, rarely found a fit so perfect that I could not enter the blade at one or more points.

I have eliminated all the refinements upon which exact scientific analysis of the subject would insist, such as changes of temperature, moisture, and other conditions which are more or less insignificant in the practical work. I have based the figures on the ratio of 6 to 1 in comparing the resistance of the ordinary soft steel rails with that of our usual commercial copper, and for the latter I have followed the ordinary tables adopted by the wire manufacturers.

I have not discriminated between the different assignable values for resistance in the various forms of rail bonds, and have calculated only for the specific metal used in the comparisons, leaving the merits and demerits of the form out of the question. I will refer to the last later on.

In studying general situation prior to constructing, in the spring of 1891, the railway system of Lincoln, Neb. (of which my firm were supervising engineers), I investigated the subject somewhat closely. Though at the time, and under the local conditions, an advocate of iron rail bonds, I was and am yet convinced that supplementary ground wires are an unwise extravagance. I will try to give you the reasons for this belief.

In steel rails we usually say that every 10lb. weight per yard means one square inch of cross-sectional area. And every square inch of such area can be brought to terms of copper by dividing by 6. The resistance is easily determined, and we thus readily arrive at some important results for comparison. For example, take the average city railway rail as being a 70lb. girder. Its area is substantially seven square inches, and the four rails of a double track make 28 square inches, equal to a single steel bar 4in. thick by 7in. wide. This is electrically equal to a bar of copper having 4·66 square inches area, or, in other words, a copper conductor 1in. thick and almost 5in. wide. With such a magnificent path for our returning current, does it not seem absurd to supplement it with a No. 0 wire, whose area is that of a rod a little over a ¼in. square? But when we find the above rail resistance per mile to be but ·0086 ohm, while that of the No. 0 wire is just 60 times greater, the absurdity seems to grow, and it becomes a case of sending a very small boy to do a very big man's work with the man standing idle on the spot.

Calculating in like manner for some usual weights of rails, I obtain Table I.

TABLE I.—Double Track.

Size of rails.	Total sectional area.	Equivalent in copper.			Resistance per mile.
		Area.	Thick.	Wide.	
lb.	sq. in.	sq. in.	in.	in.	ohm.
50	20	[illegible]	1	3 33	0·0121
60	24	4·00	1	4·00	0 0101
70	28	4 66	1	4·66	0 0086
80	32	5 33	1	5 33	0·0075
90	36	6·00	1	6·00	0·0067

As it would be tedious to carry all these into further comparisons, I will carry the analysis out mainly on the 70lb. rail, with one reference to the big 90lb. rail now being extensively used in large cities.

TABLE II.—70lb. Rail, Double Track.

Case.	Description.
1	No. 4 copper bonds, connectors, and two No. 0 copper supplementaries.
2	No. 4 copper connectors to rail ends, two No. 0 copper supplementaries.
3	36in. No 0 iron bonds, single. No supplementary.
4	36in. No. 0 iron bonds, double. No supplementary.
5	36in. No. 0 copper bonds, single. No supplementary.
6	12in. No. 0 copper bonds, single. No supplementary.
7	36in. No 00 copper bonds, single. No supplementary.
8	12in. No 00 copper bonds, single. No supplementary.
9	36in. No. 000 copper bonds, single. No supplementary.
10	12in. No. 000 copper bonds, single. No supplementary.
	90lb. Rail, Double Track.
11	No. 4 copper connectors to rail ends, four No. 0 supplementaries.
12	12in. No. 0000 copper bonds, double. No supplementary.

Cases 1, 2, and 11 are given as representing the system on which probably a large majority of electric railways have been constructed. A few roads have the supplementary doubled along both tracks, and a few have used slightly larger connecting wires than No. 4 B. & S. But I am trying to give the average of what has been accepted as first class work, and will try to show it can be vastly improved. The West End and the Brooklyn City Railroad Companies laid their tracks with double supplementary copper wires (No. 0 B. & S.), but found them totally inadequate, and now have put up many miles of huge return feeders or mains at great cost. Even these are inadequate. In Brooklyn these return mains (500,000 circular mils) are, when possible, suspended on the elevated railroad structure. I am informed that occasionally the insulation scrapes off and the return main makes contact with the ironwork. Heat enough is developed at this leak to soften the insulation for many feet, thus showing that the resistance of the main return is still too high.

Taking the various cases set forth in Table II., I have constructed another table, and for the sake of fair comparison I have made the calculations on the same basis of elimination as previously noted. I am not aware that the subject has heretofore been followed up to this extent, and I think it will be found interesting, and perhaps important.

Of course, in localities favoured all the year round with wet ground, the above table would be seriously astray; but, as I have said, the table is based upon the most unfavourable condition—namely, earth frozen hard for 2ft. or 3ft. deep, and earth conductivity practically nil.

(*To be continued.*)

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE I.

(*Concluded from page 305.*)

Variation of Efficiency and Fuel Consumption in Internal Furnace or Explosion Engines.—Gas and liquid fuel engines receive their charge at atmospheric pressure as well as exhausting into the atmosphere. Hence in a complete cycle the resultant back pressure loss is comparatively small. The engine friction, however, is rather larger than in steam engines, and appears to be independent of the load. Hence the mechanical efficiency decreases at light loads. Also at light loads the combustion is in some cases less perfect, or proceeds more slowly, and this is a cause of loss. It is well understood that gas and petroleum engines should be worked as far as possible at full load. At the Dessau electric station, which is worked with gas engines, large secondary batteries are used to store the surplus energy when not required for supply, and to obviate the necessity of working the engines at light load. On the other hand, engines of this type have the very great advantage that they can be started in a few minutes when required, and stopped whenever they are not wanted. There is, in a station worked with such engines, no loss like that due to irregular working of the boilers.

* Howard Lectures delivered before the Society of Arts.

TABLE XI.—Fuel Consumption in Internal Furnace Engines.

Brake load in per cent. of load at full load.	Gas engine Cubic feet of gas per brake h.p. hour.	Oil engine. lbs. of oil per brake h.p. hour.
100	21·65	1·00
75	23·78	1·13
50	28·05	1·40
25	40·85	2·20
12½	66·45	3·80

It will be seen that the cost in fuel per horse-power increases greatly at light loads.

COST OF STEAM POWER.

The probable cost of steam power in any given case can only be determined by careful estimates in which local conditions are taken into account. The cost of coal, facilities for obtaining water, the cost of labour, even the type of engine and character of the buildings required, are more or less different in different cases. Certain typical cases may, however, be taken, and an average estimate made of the cost in such cases. The cases will be taken first of engines used in industry and working a regular number of hours daily with a nearly regular load. This will afford some indication as to how far motive power, supplied from central stations by some method of transmission, can be used economically in place of power generated locally by steam engines. Then the special case of the cost of power generated by steam in central stations for distribution will be considered.

Cost of Engines, Boilers, and Buildings.—With engines of 100 h.p. or more, the cost can be pretty definitely stated, and the total cost of engines and boilers per horse power does not vary very greatly with the type of engine adopted. For if a cheaper and simpler type of engine is selected, then, its efficiency being less, the boilers have to be larger; but, with small engines, the cost per horse power increases very considerably, both because small engines are less efficient, and because they are more expensive to construct.

It will be assumed for the following estimates that the total cost, erected, of engines and boilers, with pipes and auxiliary apparatus, and such buildings as are necessary, may be taken to be as follows:

TABLE XII.—Cost of Steam Plant.

Indicated h.p.	Cost per i.h.p. in £.	Effective h.p.	Cost per h.p. in £.
1	56	·7	80
10	30	7·5	40
50	24	40	30
200	20	165	25

In determining the annual cost, interest will be taken at 5 per cent., and maintenance (repairs) and depreciation at 7½ per cent.

Cost of Coal and Petty Stores.—In the following estimates coal will be taken at 20s. per ton. The amount of coal required must be calculated so as to allow for lighting up boiler furnaces; for waste due to cooling of boilers and brickwork when steam is let down; and for working auxiliary apparatus, such as feed pumps.

TABLE XIII.—Working Cost of Steam Plant.

Indicated h.p.	Coal per i.h.p. hour.	Effective h.p.	Coal per effective h.p. hour.
	lb.		lb.
1	8	·7	11½
10	5¼	7·5	7
50	2¾	40	3½
200	2·0	165	2¼

The cost of petty stores will be taken at 0·25lb. per effective horse-power per annum in the case of moderately large engines working 10 hours a day. In other cases a proportionate estimate will be made.

Cost of Labour.—For driving, stoking, and cleaning an allowance of £1·2 per annum per effective horse-power for 3,000 hours, or £0·6 per annum for 1,000 hours, will be made. In the case of engines of 10 h.p. or less, however, the labour reckoned on the horse power costs considerably more.

The results given in these tables are plotted in Figs. 8 and 9. The extremely rapid increase in the cost of working for small powers is very striking.

Annual Cost of an Effective Horse-power per Annum obtained by an Engine Working with Dowson Gas.—It will be useful to place alongside these estimates of the cost of a steam horse-power an estimate of the cost of a horse-power obtained from a gas-engine. For comparison, the very careful estimate of Prof. Witz may be taken, based on experimental trials of an engine of 112 i.h.p., or 77 effective horse power, worked with Dowson gas. The total cost of the engine, with pump and pipes, was £944, or £8·2 per indicated horse power. The gas generator cost £280, or £2·5 per indicated horse power. Foundations and erection (without buildings) cost £68, or £0·61 per indicated horse-power.

TABLE XIV.—Cost of an Effective Horse-power per Year of 1,000 Working Hours. The Engine Working Regularly with Nearly Full Load.

—	Indicated horse-power of engine.			
	1	10	50	200
	£	£	£	£
Interest at 5 per cent. on engines, boilers, and buildings	4·00	2·00	1·50	1·25
Maintenance and depreciation at 7½ per cent.	8·00	3·00	2·25	1·88
Coal at 20s. per ton	5·13	3·12	1·56	1·01
Petty stores	0·50	0·30	0·20	0·15
Labour	6·25	3·00	0·80	0·70
Total cost of one effective horse-power per year of 1,000 hours	23·88	11·42	6·31	4·99
Cost (in pence) per effective horse power hour	5·75	2·84	1·51	1·20

TABLE XV.—Cost of an Effective Horse-power per Year of 3,000 Working Hours. The Engine Working Regularly with Nearly Full Load.

—	Indicated horse-power.			
	1	10	50	200
	£	£	£	£
Interest at 5 per cent. on engines, boilers, and buildings	4·00	2·00	[illegible]	1·25
Maintenance and depreciation at 7½ per cent	6·00	3·00	2·25	1·88
Coal at 20s. per ton	15·39	[illegible]·36	4·68	3·03
Petty stores	0·75	0·45	0·30	0·25
Labour	12·50	6·00	1·50	1·20
Total cost of an effective horse-power per year of 3,000 working hours in pounds	38·64	20·71	10·23	7·61
Cost of an effective horse-power hour in pence	3·10	1·66	·82	·61

The total cost, without buildings, was therefore £11·5 per indicated, or £17·2 per effective horse-power a cost about equal to that of a steam engine plant of the same power. Prof. Witz takes the cost of anthracite at 25s. a ton, and coke at 28s. a ton. He allows for interest and depreciation 15 per cent. The gas consumption is taken at 84 cubic feet per effective horse-power hour, which allows nothing for irregular working. Prof. Witz's figures are reduced to a year of 3,000 working hours.

TABLE XVI.—Cost of an Effective Horse-power in a Gas engine, using Dowson Gas, per Year of 3,000 Working Hours.

Interest and depreciation at 15 per cent.	£2·78
Anthracite and coke	2·36
Petty stores	·40
Wages	·96
	6·50

The cost appears to be slightly less than that of a steam-engine of corresponding power. The cost is equivalent to 0·51 pence per effective horse-power hour.

Cost of Steam Power in Central Stations.—The case of a central station worked by steam power differs from those previously considered in consequence of the excess of plant required, and the waste due to working against a varying load.

In such a generating station, whether supplying electricity or energy in any other form, it is usually necessary to work night and day. Part of the engines must work 8,760 hours in the year; but for a large fraction of the time much of the plant is standing idle. The demand for motive power purposes is greatest during the day hours, that for lighting during the evening hours; during part of the night the demand for any purpose is very small. It follows that the plant required must be much larger than that which would be required to meet the average demand if that could be supplied uniformly during the 24 hours. Further, there must be a reserve of power, so that any engine or boiler can be laid aside for examination or repair without hindering the work of the station. That reserve will be taken to be 25 per cent. of the whole power.

The earning power of the plant depends on the average demand and average rate of working. The coal and labour depend on this also, but are increased in consequence of the uneconomical conditions of working. The interest and depreciation must be calculated on the maximum output of which the plant is capable.

Working Cost of Engines Reckoned also at per Indicated Horse-power at Full Load.—The cost of coal will be taken at 7s. per ton. The cost of oil and petty stores will be taken at £0·28 per indicated horse-power per year. Labour is a difficult item to estimate, because it depends so much on management and conditions of working. The cost of labour will be taken at £2 per

indicated horse-power. The following rates will be assumed for interest and depreciation:

	Per cent.
Interest on capital cost of plant	4
Maintenance and depreciation:	
Buildings	2
Machinery	7½

From what has been said, it will be seen that the annual cost of a horse power depends on the distribution throughout the day of the work to be done. If the work is regular, and the engine works at nearly full load, the cost of the horse power is comparatively small; on the other hand, if the work is very irregular, larger engines are required, the working is inefficient, and the cost is comparatively large.

Two limiting cases will be considered:

Case I.—Conditions similar to those of an engine pumping to reservoirs night and day all the year round. Such an engine may be taken to work 90 per cent. of the whole year, or of 7,884 hours in the year. For one effective horse-power of work done there must be exerted 1/0·85 = 1·176 i.h.p., allowing for engine friction. And for every 1·176 i.h.p., engines of 1·47 i.h.p. must be provided to allow the necessary reserve.

Case II.—Engines working in conditions similar to those of an electric lighting station. The engines work all through the year, but the maximum demand is four times the average demand. For every effective horse power the engines must exert, neglecting the variation of mechanical efficiency, 1·176 i.h.p., and for every 1·176 i.h.p. of average demand there must be provided engines capable of exerting 4·70 i.h.p. during hours of maximum demand. Further, to allow a reserve, the engine power in the station must be 5·87 i.h.p. for every effective horse-power of average demand.

Case I.—Engine Working on a Very Regular Load, in Conditions similar to those of an Engine Pumping to a Reservoir.—Here, for one effective horse-power exerted during 7,884 hours annually, engines of 1·47 i.h.p. must be provided. Such engines may be taken to use 14lb. of steam per indicated horse power in test trials; but in ordinary work, 7½ per cent. more must be allowed for leakage, working auxiliary engines, and less careful attention. This makes the consumption 15lb. of steam per indicated horse-power, or 15 × 1·176 = 18lb. per effective horse-power hour. At 9lb. of steam per pound of coal, allowing also 5 per cent. for lighting and banking fires, the engine would use 2·1lb. of coal per effective horse-power hour. There are very few engines working with quite so low a consumption.

Cost of Installation.

Cost of engines for 1 effective horse-power or with reserve 1·47 i.h.p. = 1·47 × 8·9	£13·3
Cost of boilers = 1·47 × 4·8	7·0
Cost of buildings, 1·47 × 6·0	8·8
Total	£29·1

Annual Cost of Working per Effective Horse-power.

Interest at 4 per cent.	£1·164
Maintenance and depreciation:	
Buildings, at 2 per cent.	0·176
Machinery, at 7½ per cent.	1·522
Total fixed annual cost	2·862
Coal, 2·1lb. for 7,884 hours, at 7s. per ton	2·587
Petty stores	0·327
Driving, stoking, and cleaning	2·334
Total annual cost	£8·110

This is equivalent to 0·24 pence per effective horse-power hour.

Case II.—Engines Working with Very Variable Load in Conditions similar to those of an Electric Lighting Station.—Here, for one effective horse-power supplied, on the average throughout the year, engines of 5·87 i.h.p. have to be provided. On account of the inefficiency and waste due to the variation of the load, it is best to estimate the steam and coal from experience in similar cases. Probably, no electric lighting station at present works with quite so low a consumption as 6lb. of coal per hour per electrical unit supplied. A consumption of 9lb. is probably much more common in the best-managed stations. Six pounds of coal per electrical unit corresponds to 3·8lb. per effective horse-power hour.

Cost of Installation.

Cost of engines for one average effective horse power, with reserve 5·87 i.h.p. = 5·87 × 8·9	£52·2
Cost of boilers = 5·87 × 4·8	28·5
Cost of buildings = 5·87 × 6·0	35·2
Total cost	£115·9

Annual Cost of Working per Effective Horse power.

Interest at 4 per cent.	£4·64
Maintenance and depreciation:	
Machinery, at 7½ per cent.	6·05
Buildings, at 2 per cent.	0·70
Total fixed annual cost	11·39
Coal, 3·8lb. for 8,760 hours at 7s. per ton	5·20
Petty stores	0·33
Driving, stoking, and cleaning	2·33
Total annual cost	£19·25

This is equivalent to 0·51 pence per effective horse-power exerted on the average throughout the year.

Cost of a Horse-power at Existing Electric Lighting Stations.—It is, perhaps, not entirely fair to take the cost of working of electric lighting stations as a guide to the cost of steam power. They have been recently established, they work under difficult conditions, and the best methods of economising cost have probably not yet been arrived at. On the other hand, they are central stations of the kind discussed in these lectures, and accounts of the cost of working are published in returns made to the Board of Trade.

To be as fair as possible to electrical engineers, the case of Bradford may be taken, where, according to the returns, a unit of electricity supplied is generated more cheaply than at any other station. In dealing with the figures in the returns, the cost under the heading "Salaries of manager, engineer, etc.," and that under the heading "Redemption fund," are discarded. Further, half the cost under the headings "Depreciation" and "Repairs and maintenance," is also subtracted, because under these headings are included charges not belonging to the cost of generating power. It would not make much difference if a larger or smaller fraction had been subtracted. After making these deductions, the cost of a unit of electricity supplied at Bradford mainly, if not entirely, attributable to the cost of producing power is 2·1d. Now the mechanical value of an electric unit is 1·34 horse-power hours. Taking the average efficiency of the dynamo at 0·85, then one unit corresponds to 1·34/0·85 = 1·57 effective horse-power of the engine. Calculated on this basis it

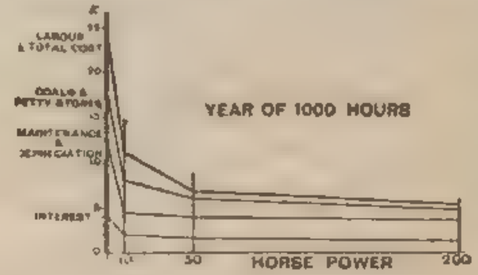


Fig. 8.

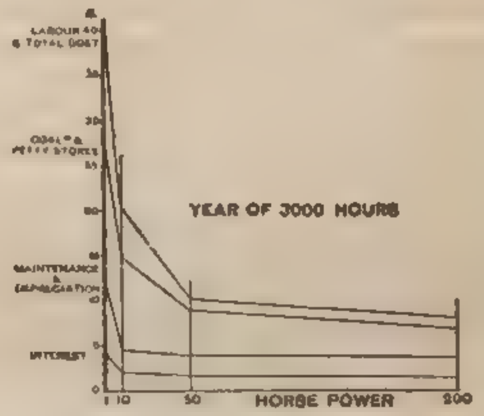


Fig. 9.

appears that the cost of an effective horse-power per year of 8,760 hours at Bradford is £49. The cost of coal and petty stores alone, exclusive of all charges for labour, interest, and depreciation, is £14·6. At most other stations for which returns are made, the cost reckoned in the same way is considerably greater.

BRADFORD CORPORATION ELECTRICITY SUPPLY.

[The Bradford Corporation being the first to elect for electric lighting has had the longest experience, and its periodic accounts are carefully read and examined by many authorities. We have pleasure in now giving the latest report, bringing the accounts up to June 30 of this year, and venture to say that these figures prove beyond all doubt the success of the undertaking.—Ed. *E. E.*]

By the desire of several members of municipal corporations, and of others interested in the development of the application of electrical energy to industrial and other purposes, I have prepared the following brief description of the progress of this, the earliest municipal undertaking of its kind, from the commencement to the present date. By the courtesy of the Bradford Corporation there is also appended a brief but complete financial statement, taken from the official six monthly accounts of the Corporation. The object of this descriptive statement being not merely to illustrate the commercial success which has attended this enterprise, but also to refute the grave misstatements respecting this electric

installation which have been made by persons who cannot plead ignorance of the subject. These misstatements, which have appeared in the public newspapers, refer to the Bradford electricity supply (and to others laid down upon similar lines) as being a mistake, both electrically and financially and one not likely to be again repeated by other municipal bodies. The fact, however, that this electrical enterprise (as the accounts show) has, within three years from the commencement of the supply, not merely met all its current expenses, including the interest on borrowed capital, and its proportion to the sinking fund for the repayment thereof, but has also paid off all of those expenses which had accrued during the construction of the works, and yet can manage, besides the above payments, to set aside regularly a further balance, and a substantial one, too, towards a reserve fund for depreciation of plant, is one that is not likely to prejudice municipal authorities against this or other similar "continuous"-current "low pressure" installations. Especially, when the relative financial position of the electrical companies using the above system, and of those employing "high pressure alternating currents" as evidenced by the Stock Exchange quotations of their respective shares shows so much, generally, to the disadvantage of the companies using alternating currents. There is yet another matter which is forcing itself into prominence, and of which municipal authorities, at least, must take cognisance. It is the fatal and unfortunately increasing number of casualties which have resulted from the use of "high pressure" combined with the "alternating" current.

JAMES N. SHOOLBRED, M.I.C.E.

13, Victoria-street, S.W., Sept. 15, 1893.

BRADFORD CORPORATION ELECTRICITY SUPPLY.

This electric installation, which was inaugurated on September 20, 1889, is on the "continuous" current system, and it is intended for a supply at "low pressure" for lighting, motive power, storage, and other applications, both industrial and domestic. The district at present supplied is situate in the centre of the town, and it comprises those streets which contain the best shops, as well as a few hotels, the Town Hall, and the public markets. The central generating station at Bolton road is at the eastern edge of the above district. The buildings erected there will, when completed, contain considerably more generating plant than is there at present. This plant now consists of four steel boilers of the "Lancashire" type, each 28ft. long by 7ft. in diameter, and one Babcock and Wilcox tubulous boiler of somewhat less capacity than each of the above boilers. The steam engines—compound, non condensing—are of the inverted vertical type, each driving direct, and placed on the same bed plate with a Siemens dynamo; and they have a total output of 1,200 h.p. indicated. All of the steam engines (except one, a Marshall double acting one) are of the Willans single acting type. The total current output of the dynamos is 5,000 amperes, which is delivered throughout the district of supply at a uniform electrical pressure of 115 volts. To the above generating plant there is added a Crompton Howell secondary battery of 70 cells, and having a storage capacity of 1,000 ampere hours. This battery plays a most important part in the working of the station, both electrically and financially, inasmuch as it enables the steam engines and dynamos to be stopped, on an average, from 10 to 12 hours daily; furthermore, whilst the engines are running, it acts as a regulator, counteracting the disturbing effect of any sudden demands, or of the contrary, upon the supply. Electrical instruments, and other apparatus, for the control and measurement of the supply to the town are also fitted up at the central station.

The supply of electrical energy is carried into the town and distributed to the houses at "low pressure" by means of underground armoured cables, which are laid in the ground itself, without the intervention of any culvert, and in most cases under the footpath on each side of the street. The mains—both the feeders and the network for distribution to the houses—have been laid on what is termed the "two-wire" system; owing to its being simpler in working at the commencement, before a supply is thoroughly established. Provision was, however, made at the very outset to enable (later

HALF YEARLY REVENUE ACCOUNT.

	1890. June 30.	1890. Dec. 31.	1891. June 30.	1891. Dec. 31.	1892. June 30.	1892. Dec. 31.	1893. June 30.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Salaries and wages	367 16 8	410 17 10	418 14 3	506 15 4	639 15 10	{ 665 9 11 391 8 8	970 4 0
Coal	246 17 11	247 0 6	292 18 6	342 7 0	334 2 0	375 16 6	486 0 1
Water	33 16 4	34 0 0	34 15 6	36 19 0	38 12 0	57 7 8	62 4 8
Repairs and miscellaneous	100 11 6	204 13 3	272 7 9	431 1 8	297 8 5	532 4 2	406 10 7
Rent of land	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1
Rates and taxes	46 0 0	104 6 6	67 1 8	69 11 6	112 4 9	101 2 1	133 7 11
Bank interest and commissions	19 1 4	89 14 9	95 9 7	120 7 5	108 2 11	104 1 6	111 1 5
Total working expenses	£898 1 10	£1,174 10 11	£1,261 5 4	£1,591 0 0	£1,614 4 0	£2,311 8 7	£2,253 6 9
Balance	39 7 0	377 18 10	832 8 2	2,001 1 0	1,601 12 11	2,386 14 11	2,294 1 6
Total gross receipts	£858 14 10	£1,552 9 9	£2,003 13 6	£3,592 1 0	£3,215 16 11	£4,698 3 6	£4,547 8 3
Units sold	39,113	68,794	85,103	154,258	141,622	223,789	401,540
Price per unit	5d.	5d.	6d.	6d.	5d.	5d.	5d.

INTEREST AND SINKING FUND ACCOUNT.

	1889. Dec. 31.	1890. June 30.	1890. Dec. 31.	1891. June 30.	1891. Dec. 31.	1892. June 30.	1892. Dec. 31.	1893. June 30.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Interest on loans	467 7 5	360 9 11	360 14 0	469 16 10	545 0 6	636 18 5	719 11 3	771 11 8
Sinking fund	421 13 4	332 10 0	332 10 0	392 16 8	392 16 8	577 7 4	577 7 4	827 19 0
	£889 0 9	692 19 11	693 4 0	862 13 6	917 17 2	1,214 5 9	1,296 18 7	1,599 10 8

CAPITAL EXPENDITURE ACCOUNT.

1889. to December 31.	1890. to June 30.	1890. to December 31.	1891. to June 30.	1891. to December 31.	1892. to June 30.	1892. to December 31.	1893. to June 30.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
18,456 2 4	25,223 19 11	27,209 4 8	35,370 7 11	40,224 19 10	45,136 8 6	48,568 12 11	52,306 2 4

PROFIT AND LOSS ACCOUNT.

		£ s. d.			£ s. d.
1889	Dec. 31.—To debit of revenue	1,079 8 5	1891	Dec. 31.—By profit on half year	971 4 10
1890 {	June 30.—To loss on half year	732 6 11	1892 {	June 30.— Ditto ditto	387 7 2
	Dec. 31.— Ditto ditto	315 6 0		Dec. 31.— Ditto ditto	1,089 6 3¼
1891	June 30.— Ditto ditto	30 5 4			£2,447 18 3¼
	By balance	290 11 7½	1893	By balance from 1892	290 11 7½
		£2,447 18 3¼	,,	June 30.—By profit on half-year	825 16 10¼

on, when the increasing demands for the supply should require it) the arrangements commonly known as the "three-wire," the "five-wire," or other even higher pressure being adopted. The demand for the supply has been very steadily increasing throughout the four years that the installation has been in operation. The series of half yearly accounts hereto annexed prove this, and point to the financial success which has attended this industrial enterprise. So large has been the augmented custom that for some time all the resources of the installation have been at times very severely taxed, and notably in the arrangements for the distribution of the supply in the town. The time had evidently arrived to take advantage of the provision made for the adoption of the "three-wire," the "five wire," or some other arrangement, such as would ensure for some years, at least, largely augmented facilities for coping with the growing demands, not merely as regards lighting, but also for motive power, and other industrial and domestic applications. The Corporation, recognising the importance of the step about to be taken, and the very considerable influence it would have upon the future development of the electrical supply in their town, and in the immediate vicinity, resolved, before deciding upon any definite proposal, to obtain the highest scientific opinion available, not merely as to the extensions which might be required, but also as to the correctness, or otherwise, of the system which had, so far, been adopted. Lord Kelvin, P.R.S. (better known as Sir W. Thomson), was good enough to undertake the task. He advised the adoption for the centre of the town of the three wire, while reserving the five wire, for a future period, in the more distant parts. At an interview with the Corporation on July 19th last, in Bradford, his lordship, after having carefully inspected the present works, in reply to various questions from the members of the Electricity Committee, said that: "The committee had acted rightly in adopting the present system at the commencement of their undertaking. The possibility of adopting the three wire system at a future time was fully considered when the works were at first laid down. The three-wire system would at that time have been premature, with the comparatively small demand for the electric light then to be provided for. . . . Replying to a question from the chairman, as to the use of the 'continuous' or of the 'alternating' current with the three wire system, Lord Kelvin said: 'Continuous current was undoubtedly preferable, even in high tension (say 2,000 volts). . . . Alternating currents were a success when a transformer was in use at each separate premises, but the use of transformers involved difficulties which did not arise with continuous current. The latter is better where there are varied requirements, as for charging accumulators, driving motors, electro plating, etc. The alternating current is more difficult to transmit in large quantity than continuous current. Alternating motors were not yet well adapted for practical use.'"

The following letter has been sent to Mr. Shoolbred from the Town Clerk's Office, Town Hall, Bradford, dated 12th August, 1893:

My Dear Sir,—I congratulate you on the fact that Lord Kelvin has done you ample justice as to your electric installation here. It justifies what you have done, and adds, that if we were to begin again it would be our duty to repeat the operation; and further, that the two wire system was the right thing at the time, not only *per se*, but as being capable of having three wire or five wire system applied, if found to be advantageous.—Yours faithfully,

(Signed) W. T. McGowen.

ELECTRIC LIGHTING AT EDINBURGH.

In our last issue reference was made to a report prepared by Prof Kennedy on the electric lighting of Edinburgh. We now give the report as follows:

On April 8 last I had the honour of making a preliminary report to the Electric Lighting Committee of the Town Council, and during the following month I received instructions from the town clerk to draw up a complete scheme for the lighting of the city. I have since then spent some time in Edinburgh, and have gone very thoroughly into the whole matter, and have pleasure in now presenting the following report.

So far as the figures in my preliminary report are concerned, I may say at once that further investigation has substantially corroborated them throughout, and I have not, therefore, anything to modify in what I originally stated, except that I find the total cost will be somewhat less than I had estimated it, although I have provided for slightly increased plant.

The first question which I had to examine was that of the area to be lighted. The district in which I advise that mains should be laid covers practically the whole business part of the city, from the Register House to Donaldson's Hospital, and the principal residential streets and terraces, along with as much of the business part on the south side as has been scheduled in the Act, with the addition of Cockburn-street and a part of High-street. I should not have included the streets nearest the University Buildings at present, but have no alternative, as they are among those scheduled in the Act.

The extent of the public or street lighting is a matter which must essentially be left for the decision of the Town Council. I understand that it is decided that the principal streets should be lit by arc lamps. This includes Princes-street and George-street, with the connecting streets between them, Leith street and the bridges, as far south as the limits of the scheduled district, High-street up to George IV. Bridge, Bank street, the Waverley Bridge, and the Mound. The lighting of the streets would involve the use of about 130 arc lamps and the cost of these lamps, with the lampposts, cables, and road work, and all necessary plant in the station for supplying current to them is included in my estimate.

The determination of the best system to be adopted is, of course, the matter which has taken up the greater part of my attention. The question is, in almost all cases, a difficult and complicated one, and Edinburgh has been no exception to this rule. The actual electric light as given out by incandescent lamps is absolutely the same, and equally good, by whatever system generated. There are, or may be, differences between the different systems in capital cost, in cost of production, and in general convenience of application and ease of regulation, but not in quality of light. Bearing these points in mind I have found it necessary to make detailed estimates of several different schemes for lighting the city by different systems, and my recommendation is the result of a comparison of these. In regard to the two principal points—namely, the double requirement of minimum initial cost, coupled with minimum cost of working—it may, of course, happen that both these minima cannot be reached by the same system in any given place, and in that case the one has to be balanced against the other. But in addition to these obvious considerations, I have had to bear in mind two other very important ones—namely, (1) that, if possible, the system used should be such that one central station should serve for the whole of the city for at least a long time to come; and (2) that it should be such that very large extensions can be made as required without going beyond the original lines, and without unreasonable additional cost.

From this point of view I found it necessary to compare the possible future demand in the south of Edinburgh with that probable in the northern district now to be supplied. I have no doubt that a demand will grow up in the southern district. If this district had been at all likely to yield as large an income as the northern district, it would probably have been worth while to put down a special station for it, in spite of the inevitable drawbacks of having more than one central station. I find, however, from a careful examination of the number of houses and length of streets in it, that it will require about twice the length of mains to supply it that is required by the northern district, and that at the same time it can never be expected to yield much more than a quarter the income of the northern district. The cause of this is, of course, the fact that it is mainly a residential district, and, further, that its houses are somewhat widely separated from each other, instead of being built in compact terraces. Under these conditions, it becomes specially important that a second station should not have to be built for this district, as such a station would be so much smaller and so very much less profitable than the northern one. These circumstances have decided me to recommend to you a plan by which both districts should be supplied, as time went on, from the one station.

For a compact urban district like northern Edinburgh, in which the lighting will be very heavy, there are practically four possible systems, with various modifications. These are (1) A three wire system, something like that which I have used in Glasgow; (2) a five wire system, such as that which is about to be started in Manchester; (3) some modification of the "Oxford" system; and (4) a combined high and low tension system, such as that used by the City of London Company. I have, after consideration dismissed the five wire system and the Oxford system as being unsuitable under the circumstances, and have worked out in detail only the other two. I have proceeded on the assumption that the central station should supply current sufficient to keep 20,000 lamps of 8 c.p. alight at one time, which is probably equivalent to about 40,000 lamps actually installed. This is the figure which I gave in my preliminary report. For this purpose the station should contain (whatever the system used) engines of about 1,500 i.h.p. (including reserves), with the corresponding dynamos or alternators and boilers, etc. With a three wire system there would be heavy trunk mains acting as feeders, and delivering current to the distributing network at various points throughout the town at a pressure of about 220 volts, but there would be no machinery or apparatus of any kind beyond the walls of the central station. With the high tension system the current would be delivered from the station at about 2,500 volts and carried by small high tension feeders into some six or eight transformer sub stations, placed in cellars or other suitable positions throughout the district. In these sub-stations there would be placed the necessary transformers and other apparatus for redistributing the current by low-tension sub feeders into the network at 220 volts.

The total cost of the plant in the central station, and the space taken up by it, I find to be practically the same in both cases. The cost of the distributing mains is also practically the same in both cases. The cost of the low tension feeders also work out the same as the total cost of the combined high and low tension feeders, the transformer sub-stations and the transformers themselves, with their instruments and connections. The total cost in each case, including an allowance of £10,000 for buildings, and including also the arc lighting plant, but not including the cost of land, will be about £80,000, or £5,000 less than the sum stated in my original estimate. The cost of doubling the capacity of the plant and mains, when this should become necessary, would be about £30,000 in the first case, and about £28,000 in the other. There is thus no practical difference in capital cost between the two systems, and so far as expense goes the decision as to which is best in this case must depend on the cost of working them. The working costs for a three wire system are well known, as many are in operation. The cost of working a combined high and low tension system can hardly yet be said to be known,

as no system of this kind has been at work anywhere for a sufficient length of time. It has, unavoidably, the considerable additional annual expense of the rents of the transformer sub-stations and the wages of the men employed to attend to them, and, including this, the lowest estimate which I can make of the difference in cost of production between the two systems is 0·5d. per unit on 680,000 units per annum; the difference might well be much greater. The balance of advantages, therefore, seems to me very much in favour of the use of a three-wire system for the northern district, and I recommend the adoption of this system.

In the southern district—for, as I have already said, I consider myself bound to consider this district as well as the other, in order that you may not be saddled with arrangements which shall prove unsuitable in the future, however advantageous for the present—the balance of advantages is altogether altered. The average length of feeders, which in the northern district is about three quarters of a mile, would be more than doubled, and the heaviest consumption would be at the ends of the longest feeders. In many places, too, the houses are so far apart that the cost of low tension distributing mains would be disproportionate to the income likely to be derived from them. These conditions are just those in which the advantages of an alternating current system make themselves felt. Not only is the additional outlay caused by the increased length of feeders much less than with low tension, but it is also possible to supply current to scattered terraces and isolated houses with transformers in the separate houses, at the same time using special transformers with low tension distributing mains wherever the demand for current justifies this. I think, therefore, that in supplying the southern district it will be advisable to use an alternating current high tension system (at not less than 2,500 volts), laying down low tension network wherever it may be found worth while to do so.

The local conditions which I have briefly summarised above therefore indicate that a low tension system should be adopted at once for the northern part of the city, and a high tension system for the southern part when it has to be supplied, and for any other isolated or outlying parts, such as the terraces on the Calton Hill. I have already said that I thought the whole city should be supplied from one station, at least until the demand was very much greater than anything at present contemplated.

There are, of course, certain obvious inconveniences in the use of two systems from one station, but these exist much more in imagination than in reality. The boilers, steam pipes, pumps, and buildings would be the same for all the plant, and there is no reason why the same type of engine, at any rate, should not be used throughout. Practically, the double system involves merely the use of electrical machines and switchboards of two different types in the same station, and I see nothing in this which is sufficient to justify me in rejecting, for either district, the plan of supplying it with electrical energy which appears undoubtedly the best for it. I recommend, therefore, that the central station should be so arranged that extensions for the lighting of the southern half of Edinburgh, when this is required, can be made on an alternating current system such as I have mentioned.

If the station were to be entirely a continuous-current station, I should have recommended that series arc lighting machines, of the usual construction, driven by separate engines, should be used for the street lighting, as has been done in Glasgow. As, however, there will in any case no doubt be alternators in the station before long, I recommend that two alternators be put down at once and used for arc lighting by the employment of Mr. Ferranti's constant-current commutators. So far as I have seen this apparatus it seems to be successful for the purpose of supplying a current suitable for the working of arc lamps in series, and its use with alternators will have the enormous economic advantage that special plant will not be required for the arc lighting, which can be worked from the ordinary switchboard used for the alternating currents.

When working out the scheme which I have described, I found that it would have been both convenient and economical to use one or more sub-stations containing gas engines driving dynamos. Such stations would entail very little additional expense in the way of attendance, as they would only be worked during the hours of maximum load, and then only during part of the year. They would also have allowed the cost of the mains to be considerably reduced. I regret, however, that the final decision of the Gas Commissioners, of which a copy has been sent to me, appears to render it impossible for any scheme of this kind to be carried out economically.

In my preliminary report I stated that the total works cost, including office expenses, should be about 3d. per unit when your output reaches 300,000 units per annum, and 2·5d. per unit when it is 680,000 units per annum. The interest and sinking fund on £100,000, if taken at 5 per cent., amount to 4d. and 1·75d. per unit respectively, making the total costs 7d. and 4·25d. per unit for the two outputs. It cannot be expected that the station should pay its way during its first year of working, but where so large a portion of the cost is a fixed charge it is, of course, of the greatest importance to do everything to secure the largest possible output at the earliest possible time. From this point of view I believe it would be the best and safest policy to start at once with a charge of 6d. per unit, the charge which is now made over nearly the whole of London. In this estimate of output and cost I have, as before, omitted the arc lights entirely, as I presume that the street lighting will be carried out for yourselves at cost price. The rate paid by the Corporation of the City of London is £27 per annum for each arc lamp, including trimming and the supply of carbons; no doubt it might cost you somewhat less.

Prof. Kennedy concludes by giving a list of streets, etc., in *which it is proposed to lay distributing mains.*

BUSINESS NOTES.

Capetown.—Telegraphic communication has been restored between Capetown and Victoria.

Paignton.—An electrical firm has written to the Local Board offering to light the town by electricity.

Western and Brazilian Telegraph Company.—The receipts for the week ended September 22 were £3,223.

West Ham.—The Town Council has deferred the consideration of the question of electric lighting for six months.

Clerkenwell.—The Vestry have declined to grant an extension of time for the completion of the electric light station.

Gravesend.—The Mayor has interviewed the Postmaster with a view to an all night telegraphic service being instituted.

Cuba Submarine Telegraph Company.—The receipts for the month of September were £295 less than for the corresponding period.

Direct Spanish Telegraph Company.—The receipts for the month of September were £146 less than for the corresponding period.

Eastern Telegraph Company.—The receipts for the month of September were £55,567, as against £55,710 for the corresponding period.

Northampton.—The surveyor to the County Council reported last week that the putting in of the electric light in the judges' lodgings had cost £260.

Bayswater.—The Wesleyan chapel has been electrically equipped by Messrs. Money and Nash, there being 73 incandescent lamps installed.

Plant Wanted.—The Northern Co-operative Company, of 54, Loch-street, Aberdeen, require offers for supplying boiler, engine, dynamo, and other electrical plant.

Situation Vacant.—An electrical engineer is required for the training ship "Shaftesbury," off Grays, Essex. Particulars will be found in our advertisement columns.

Tenders Required.—The Rivers Committee of the city of Manchester, as will be seen from our advertisement columns, invite tenders for the supply and fixing of electrical plant.

Islington.—Mr. Albert Gay informs us that he is no longer connected with the House-to-House Company, having been appointed electrical engineer to the Vestry of St. Mary, Islington, N.

Wandsworth.—The Vestry have granted an extension of six months for the County of London Electric Light Company to comply with the seventh section of the provisional order issued to them.

Henley's Telegraph Works Company, Limited.—We understand that dividend warrants have been posted for the half-yearly interim dividend on the preference shares at the rate of 7 per cent. per annum.

Fulham.—The question of providing a telephone for the Vestry has been referred to the Town Hall Committee for consideration. The Vestry are enquiring about the position of other local authorities as regards electric lighting.

Haslingden.—The Board of Guardians have authorised the chairman to sign a petition which is to be presented to the Corporation of Rawtenstall, requesting that the fire-engine station be connected with the National Telephone system.

Willenhall.—The Local Board have instructed the clerk to make enquiries as to whether the authorities would connect Willenhall by telephone with Wolverhampton and Walsall, in order that the brigades might be summoned in case of a fire occurring.

Appointment.—Mr. Lee has been appointed engineer to the Southampton Electric Light and Power Company in the place of Mr. R. A. Scott Moncrieff, who has left to join Messrs. Kilburn and Co., the Calcutta agents for Messrs. Crompton and Co., Limited.

Shoreditch.—The Electric Lighting Committee of the Vestry have requested Messrs. Manlove, Alliott, and Co. to report for £10. 10s. on the cost of burning 20,000 tons of dust per annum, with a view to the resulting heat being utilised for electric lighting purposes.

A Large Blast.—A huge mass of rock has been blasted at the Dinorwic Quarries at Llanberis. All the preparations for the great blast were carried on by the aid of the electric light, an installation being erected on the spot by the British Electric Light Company.

City and South London Railway Company.—The receipts for the week ending October 1 were £795, against £786 for the same period last year, or an increase of £9. The total receipts for the second half year of 1893 show an increase of £455 over those for the corresponding period of 1892.

Telegraphy.—An agreement has been signed whereby telegraphic communication is to be established between Llandyssul and Llangranog. Operations will commence in the spring. It has also been decided to establish telegraphic communication between Llandyssul and Velindre, Llangeler, Carmarthenshire.

Bank Lighting.—The new buildings of the London and Midland Bank at Bradford have been equipped with the electric light, there being installed 45 16-c.p. lamps. The installation has been put up by Messrs. Rosling and Matthews, of Bradford, and the fittings have been made and supplied by Messrs. Hunt, of Birmingham.

Brazilian Submarine Telegraph.—The Directors of this Company recommend a final dividend of 3s. per share, making 6 per

cent. for the year ended June 30, and a bonus of 1s. per share (both tax free), leaving a balance of £10 533, out of which £7,000 has been placed to reserve, increasing that fund to £638,075, and £3,533 being carried forward.

York The Technical Instruction and Public Library Committee of the Town Council have agreed to the lighting of the institute building by electricity, and they ask the sanction of the Council to the acceptance of the tender of Messrs. Benson and Co., of London for carrying out the wiring of the building in connection therewith for the sum of £314.

Paddington. -- The Paddington Baths Commissioners have decided to place two electric lights of 52 c.p. in front of the baths. This is a modification of the specification of the contract, and the mover of the proposal at a meeting of the Commissioners said he was sure that Messrs Dawson and Hammond, the contractors, who were obliging people, would consent.

Canterbury.—The following report of the Electric Lighting Committee was adopted at a meeting of the Town Council last week "The committee recommend that a letter be written to the Board of Trade stating that the Council are perfectly satisfied with the steps the Canterbury Electricity Supply Company, Limited, are taking to carry out their agreement with the Council."

Tweedmouth. –The sawmills of Messrs. Allan Bros. have been fitted throughout with the electric light A Parsons steam turbine and dynamo of 25 h p. supplies the electrical energy, and altogether in the various shops and offices there are nearly 200 incandescent lights. The installation, which is the first of the kind in the Berwick district, has been carried out by Messrs. A. A. C. Swinton and Co.

Picture-Lighting. The contract for the electric lighting in connection with Messrs Agnew and Son's picture gallery in Manchester has been given to Messrs Drake and Gorham, whose Manchester branch is carrying out the work. There will be about 100 lights, and a special feature in this case will be the reflectors, the contractors taking pains to obtain the best possible effect. Mr. Walter Leake is the consulting engineer.

Lewisham -The Board of Guardians have conferred with their architect, Mr Harston, as to the lighting of the new infirmary. Mr Harston estimated the cost of installing the electric light at £5 000, and put the cost of its maintenance at about the same, or, perhaps, a rather higher figure than for gas, which he calculated to amount to £250 per annum for lighting purposes apart from cooking. It was decided to light the infirmary by gas.

Morley The Corporation are prepared to receive particulars of schemes for the electric lighting of the Town Hall and the borough generally. A premium of £100 will be awarded to the scheme selected by the Council as the most suitable for the requirements of the borough. Plans and particulars are to be sent before 1st of December A copy of the conditions of the competition will be forwarded on application to Mr. R Borrough Hopkins town clerk.

Pontypool.—The clerk to the Local Board read a letter last week from Mr W. Pegler suggesting that the Board should have electric lamps fixed in prominent places in the town, the cost of which, he thought, would be about £15 each, exclusive of fixing A discussion ensued, at the close of which the matter was postponed for a month. The Chairman remarked that he did not think they could use electric lamps without the consent of the gas and water company.

Electric Lighting of Derby. –The central station is now practically complete, and will be formally started next Tuesday The occasion is to be celebrated by a banquet at the Royal Hotel, given by the Mayor (Mr Councillor Marsden, J P.). Previous to the banquet the Mayor and Corporation will proceed to the electric lighting station in Full street, where the ceremony of starting the station will be performed by Mr. Marsden A managing engineer has not yet been appointed.

Kingston-on-Thames.—The Corporation invite tenders for the electric lighting of the Town Hall, public offices, library and courts. Specifications and forms of tender may be obtained at the town clerk's office, Clattern House, Kingston upon Thames, where plans may be seen, on payment of £1. 1s., returnable on receipt of a *bona fide* tender. Sealed tenders, endorsed "Public Buildings Electric Lighting, must be delivered at the office not latter than to-morrow, the 7th inst.

Dudley. Alderman Bagott mentioned at a meeting of the Town Council on Tuesday last that recently a local manufacturer had introduced the electric light, and he thought that it might be an incentive to the Council to go more thoroughly into the matter of providing the town with a similar light. They were obtaining all information they possibly could in order to introduce a competitive light, and they hoped to be prepared shortly to give the Council some useful particulars in regard to the matter.

Taunton.—A special meeting of the Town Council was held on Monday to receive and consider a report of the Electric Light Committee, to affix the seal of the borough to the contract with the electric light company for the purchase of the works, and to make arrangements with respect to the new loans The committee reported further that they had had an interview with Dr Fleming, who would report fully on various subjects when he had considered the information which he had obtained from the officials. The recommendations of the committee were adopted.

West Calder The ceremony of turning on the electric light took place recently in the premises of the local co operative society. The society's plant, which has been in use for the past four years, is now enlarged so as to form a central station for the distribution of the light throughout the district. A large dynamo of the Elwell Parker type is used during the day to transmit power by overhead wires to motors, which in turn drive machinery belonging to the society, and in the evening the whole of the society's premises are lighted with arc and incandescent lamps.

Lighting at Lambeth The question of lighting the workhouse by electricity was again considered at a meeting of the Board of Guardians last week. In addition to the scheme propounded by Mr. Preece, that gentleman now estimated that four boilers, costing £1,600, would be required for electric and other purposes At the previous ordinary meeting of the Board Mr Lake moved that no further action be taken. Upon resuming the consideration of this motion last week the chairman put it to the Board, and it was carried without discussion.

Ipswich. -At a meeting of the Paving and Lighting Committee of the Town Council last week, the chairman said that the subcommittee as to electric lighting had arrived at the conclusion that it would be unadvisable to take any step to apply for a provisional order in the next session of Parliament, and therefore it would be well to let the matter stand over for a few months. In the early part of next year they would recommend that a report should be made to the Council, and that would involve the necessity of appointing some skilled person to advise them.

Great Missenden A meeting was recently held to further consider whether the Lighting Act should be adopted in the district comprising the village only, and also to consider a proposition of the British Volta Electric Glow Lamp Company, to provide all the plant and fittings at their own cost, and also to provide 13 electric lights each night, from September to March, for all hours from one hour after sunset to 10 15 p m., on condition that the charge to the village shall not exceed £15 per year. There was a large attendance, and it was resolved to accept the proposition of the company.

Leamington. The Vicar proposed at a meeting of the Vestry last week that the parish church should be lighted by electricity. There were many complaints about the lighting at present, and a generous parishioner had offered to advance a loan of £250, free of interest, for the purpose of covering the expenses of the installation. He proposed that the offer be accepted, and the work proceeded with Mr H Ford seconded the resolution. Mr. Whitehouse stated that the electric lighting company offered terms which would make the cost a very little more than that for gas The resolution was carried.

Worcester. At the meeting of the Board of Guardians the Building Committee recommended that instructions should be given to obtain as many gas brackets as might be required for the basement of the new workhouse Mr Winwood complained that these were not provided for in the estimate, and said that everything was done, by under estimating the gas required to curtail the expense, and to run up the estimated cost of electric lighting by including everything. Mr Edmonds said that it would be found in the end that the gas would not cost more than what was estimated. The recommendation was adopted.

Portishead In reply to an advertisement for lighting tenders, three tenders have been received by the Local Board for doing the work by electricity, by oil, and by gas. The electrical tender suggested the purchase of plant to the amount of £12,460. The oil tender was said to work out to £2 4s 6d per lamp. The offer of the Portishead Gas Company was £2. 2s. per lamp. Mr. Davis said at a meeting of the Board last week that he thought they would before long see electricity introduced Keynsham was wonderfully pleased with its electric light, and it cost less than the lighting at Portishead, where gas was used. It was resolved to accept the tender of the gas company.

Folkestone - The Mayor mentioned at a meeting of the Town Council last week that they had received a letter from Mr. Mark Parker, the gentleman who reported on the electric lighting, asking for a cheque The sum which they had agreed to pay him was 50 guineas, and he should therefore ask that this sum be added to the account for which cheques were to be drawn. Councillor Penfold moved, and Councillor Thompson seconded, that the money be paid, and a cheque was drawn for the amount. At the same meeting Councillor Thompson said with regard to the difficulty of lighting, that would all be obviated in a few months, when they had a new element for lighting.

Liverpool Overhead Railway.—The directors of the Liverpool Overhead Railway Company have this week invited subscriptions for 2,500 perpetual preference shares of £10 each, bearing a preferential dividend of £5 per cent. per annum. This issue is in addition to £75 000 in preference shares already issued out of an authorised £120,000, the Company's remaining authorised capital being £450 000 in ordinary shares, of which £375,000 have been issued, and £190,000 in debentures, £125,000 of which have been issued. The additional capital is required to complete and equip the northern extension of the railway to Crosby road South, Seaforth, authorised by the Act of 1892, and to provide additional rolling stock and new stations.

Sunderland. The question of electric lighting was considered by the Highways Committee of the Corporation last week, when a report by Prof Kennedy on the scheme of the electric lighting of some of the principal streets of Sunderland was presented The report suggested specifications for plant, and sets of plans of the work. There are 10 sets of plans, and the Committee decided to obtain 20 copies of each at a cost of £20 They also decided to have complete specifications made out in accordance with Prof. Kennedy's suggestions, and also to advertise for tenders from electrical engineers supplying and fixing the plant The Dunning street hospital is intended to be used as the station from which the electric supply will be worked.

Wrexham.—When the Town Council assembled last week the Clerk said that after the special Council meeting when it was decided to offer the Wrexham Electric Company £250 for their provisional order he wrote to the Corporation's parliamentary agents concerning the matter. He did not wish any debate to arise, and only read the letter as a matter of information. The agents stated that the proposal was without precedent and that the purchase could only take place subject to the approval of the Board of Trade and the Local Government Board. He would, now the minutes of the Council meeting had been confirmed, write to Messrs Lewis and Son making the offer subject to the approval of the authorities mentioned.

Glasgow.—Plans and specifications are in course of preparation for lighting by electricity the compulsory area, as well as a certain area beyond it. Electricity as an illuminant is being largely adopted in the warehouses and shops, and soon the Corporation will have to increase the generating plant. In Mr Anderson's Polytechnic, Argyle street, an installation of the Crompton lamp has been completed. By means of 30 of these lights, each of 1,000 c p., two of the principal floors have been lighted with satisfactory effect. By an arrangement of the lamps the dark shadow usually thrown by the arc light has been avoided, and so nearly does the light resemble ordinary daylight that the natural colours of the fabrics are in no way altered to the eye.

Leicester.—On the presentation to the Town Council last week of the half yearly report of the Gas Committee, it was mentioned that the Local Government Board had approved of the scheme for electric lighting. Alderman Lennard moved "that so much of the report as relates to electric lighting be approved, and that the Gas Committee be authorised and directed to at once proceed with the arrangements necessary for carrying out the scheme which has already been approved by the Council." He remarked that the matter had been about longer than they desired. But the Local Government Board had now sanctioned the loan of £50,000, and the work would be proceeded with without unnecessary delay. Councillor Billings seconded, and it was agreed to.

An Amalgamation.—We understand that negotiations have been for some little time in hand, and are now almost completed, for the amalgamation of the Acme Electric Works, in Ferdinand-street, Chalk Farm, N W, with the Malden crescent works of the General Electric Power and Traction Company, Limited, the two factories, joined together under one management, being intended to form a London works for the Electric Construction Company, Limited, where may be manufactured the lighter and smaller electrical appliances required by the latter in its central station and traction work, leaving the dynamos, motors, and other heavy details to be made at Wolverhampton, and storage batteries at Millwall. The combination ought to be very advantageous to all concerned.

Electric Regulating Clocks.—A company established at 39, Victoria street, Westminster, and bearing the somewhat pretentious name of "The Industrial and Mercantile Investment Corporation, Limited," is introducing into this country a system of electric clocks which has for some time been very successfully operated in Brussels and other important centres on the Continent. In this arrangement a master clock sends a momentary current from a few Leclanché cells every half minute over a circuit in which are inserted a number of magnets each actuating a dial through simple mechanism. The system is practically similar to some already promoted for the self winding and synchronising of clocks, but has the advantages of greater simplicity and cheapness to recommend it.

Perth.—At a meeting on May 1 the County Council appointed a sub committee to "enquire as to the best method of establishing telephonic communication between the various county and district officials, including the chief constable and members of constabulary throughout the county, and that the Standing Joint Committee be asked by this meeting to co-operate with the sub committee in their investigations" Both the National Telephone Company and the Post Office had been approached regarding terms, but the rentals quoted were so high as to be quite prohibitive. The sub committee report that there was little hope of being able to establish telephonic communication for county purposes until the trunk system was extended over the county generally. They, however, agree in expressing the opinion that such communication should be taken advantage of for the police and county officials as soon as it can be got on reasonable terms.

Kendal. When the Rural Sanitary Authority met last week to consider a resolution to take steps to promote a Bill for the transference of the gas and water supply to the Corporation, Mr Monkhouse said that some objectors talked about the electric light, and that he had once thought that it might be introduced into Kendal, but when it was considered by a committee it was found the expense would be such that they could not recommend it. The electric light as a lighting medium was a very long way from Kendal, and even in large places it was found that they could not supply it for anything like the price of gas. Kendal was not an advancing town, and its tradesmen were not like those of London, Manchester, and other large places where they wanted plenty of light, and could afford to pay for it. And supposing they had it, there was no town that he was aware of where their running it had ever interfered with the output of gas.

Lighting at Dublin.—A report concerning extensions has been issued by the Electric Lighting Committee of the Dublin Corporation. The committee have already spent £38,408 on account of a sanctioned loan of only £37,000, and they propose to take an additional sum of £24,348, of which £13,000 has been already authorized *by the Municipal* Council. The increase of new business is the reason for the extra outlay. The report contains statements of accounts regarding the working of the station for the two quarters from September to March. The total revenue amounted to £4,245, of which private consumers contributed £2,496 The working expenses, after deducting £248 for carbons and other stores in hand, were £376, thus leaving a balance to be carried to the net revenue account of £869. This credit is changed into a debit of £194 by the payments of interest and redemption to the Commissioners of Public Works and of the interest on the bank overdraft.

A "Revolving Reaction Engine."—What is termed a "revolving reaction engine" has been devised by Mr A Morton of Glasgow. One of two engines completed has been tested by Prof Barr and Mr Henry A Mavor. The engines have been erected in the works of Messrs Campbell, Smart, and Co., Old Dumbarton road. One is connected direct with a large Schiele fan and the other with a high speed dynamo The former runs at about 1,200 and the latter at about 4,000 revolutions per minute. The engine and dynamo are bolted on the same bed plate and the dynamo is connected with a series of incandescent lamps to act as an electric brake to the engine In the circuit there are Cardew and other voltmeters, and also ammeters. It is this engine that has been reported on by Prof. Barr and Mr. Mavor In their report they say. "The results here reported seem to indicate that considerable improvement may be expected from higher speed and better vacuum, and further experiments in the direction of still further developing the ideas embodied in the present form of engine are likely to result in greatly improved economy."

Battersea Polytechnic.—By the end of this year Battersea will be in possession of a fine polytechnic institute. It stands just on the verge of Battersea Park The building is enriched by 10 statues representing respectively Architecture, Sculpture, Painting, Engraving, Music, Poetry, Chemistry, Electricity, Mathematics, and Engineering. On the right of the entrance hall, passing into the building, is the administrative department—enquiry office, secretary's office, council room, clerks' room, and stores and a first-rate electrical laboratory. There is on the ground floor an engine room, fitted with Robey compound engines of about 120 h.p. These engines are necessary, from the fact that mechanical and electrical engineering are to be among the chief subjects of technical instruction here, as they are among the principal industries of the district of London. Besides these steam engines, there is a 12 h p. gas engine, which will be employed in driving two dynamos, with a capacity for supplying 1,100 lights about the institute. This electrical installation has been entrusted to Messrs. J. G. Statter and Co., of Victoria street, Westminster.

Killarney.—A meeting of the Town Commissioners was to have been held on Monday, but a quorum not having attended, no business was transacted. Monday was the day for holding the monthly meeting, and various important matters would come on, including the public lighting question. At present there is a strong rivalry between the gas lessees and the electric light company on the public lighting question. Not long since the gas lessees and the electric light company tendered for the lighting of the town, the former at £92 10s., and the latter at £50 The majority of the Commissioners present at the meeting—at least of the Commissioners who voted appeared to have given the contract to the gas people, notwithstanding the difference between the tenders. The electric light people allege informality, and served a notice on the town clerk and the Commissioners' solicitor, cautioning them not to perfect the contract for the gas. They also served notices on Mr. Leonard and the chairman from voting on the lighting question, they being shareholders in the gas company. Since the service of these notices the Commissioners who are the avowed supporters of gas have not attended a meeting, and, it is said, are not likely to until the matter is settled one way or another.

Camberwell.—The Vestry had placed before them last week by Mr. Wallace a report from Mr. Manville with reference to a scheme for the introduction of the electric light in the parish. Mr. Manville pointed out in his report the steps that would be necessary to be taken by the Vestry should they desire to apply for a provisional order, the estimated cost of which would be about £800. With regard to this, action must be taken almost immediately. A committee of the Vestry specially pointed out that part of Mr. Manville's report dealing with the utilisation of the ashbin refuse for the production of the electrical energy required. They recommended: "(a) That the Vestry consider the report of Mr Manville, and fix a time for a public lecture by that gentleman; and (b) that should the Vestry desire to proceed further in this matter, a joint committee of 24 members be appointed, consisting of an equal number of members from the following four standing committees—viz., the General Purposes, Sewers and Sanitary, Finance, and Plant and Scavenging—to report further thereon, and recommend to the Vestry" After some discussion it was decided to make arrangements with Mr. Manville to give a lecture as early as possible, any further step to be a matter of future consideration.

Hanley.—The Electric Lighting Sub Committee of the Town Council recommended on Wednesday that the committee should be empowered to obtain separate tenders for the electric light wiring and fittings required in all the buildings of the Corporation, and to make application to the Local Government Board for permission to borrow the money required for such work. The borough surveyor having reported that it was desirable to exercise the option provided in the contract entered into with the Brush Electrical Engineering Company for the Corporation to determine whether the company should provide the fourth set of generating plant—viz., boiler, engine, and dynamo—at a cost of £1,800, or

expend that amount in electric light street mains and appurtenances, the sub-committee recommended that the Council should give notice to the Brush Company of their intention to require the amount specified to be expended on street mains, etc., instead of generating plant, and that the borough surveyor be instructed to submit plans for the proposed mains. Mr. T. W. Harrison moved the confirmation of the minutes, remarking that the installation of the electric light was progressing, and he believed that they would be able to supply the light within the next few months. After a brief discussion, the motion was carried.

Loans for Electric Lighting.—The Finance Committee of the London Council on Tuesday reported as follows: "We have to report that we have been in communication with the Lords Commissioners of Her Majesty's Treasury with reference to the period over which loans for electric lighting purposes should be spread, and have now received a reply, dated July 29, 1893, in which their lordships accept the view urged upon their consideration with regard to the absolute necessity of all appliances and work in connection with electric lighting being kept in a thoroughly efficient condition to perform its work and the assurance that the Council would be advised by its professional officers on every application for a loan for electric lighting purposes, so that if any considerable portion of a loan was for short-lived purposes the term for that portion would be considered, and the circumstances of each case taken into account. Subject to these observations, the Treasury agree that in the case of loans of this class the whole initial cost may be taken into account in fixing the period of repayment, and that repayment may be spread over such period of years, not exceeding 30, as may seem appropriate in each case. We are glad that the Treasury has seen its way to agree to the request of the committee, as we consider that it will give increased facilities to the vestries and district boards in introducing electric lighting in their districts."

Lighting at Bolton.—The Gas Committee of the Corporation met on the 29th ult., when the proceedings of the Electricity Sub-Committee, which included tenders for the supply of transformers and underground cables, were considered. The tender of Messrs. Siemens Bros., Limited, for the supply of high tension and low tension cables was accepted, as was also that of the Brush Electrical Engineering Company for the supply of transformers. A letter was read from Mr. W. Kearns making application to be allowed to withdraw from his contract for excavation work in connection with the new electricity undertaking. Mr. Kearns attended and explained the reasons for his application. Mr. George Goodlad attended and submitted a tender for the excavation, concreting, and other work required in the erection of the generating station in place of Mr. Kearns, at the price named in Mr. Kearns's tender. The committee agreed to accept Mr. Goodlad's tender, and agreed to discharge Mr. Kearns from his contract conditionally upon Mr. Goodlad entering into a contract in writing, to be prepared by the town clerk, to provide sufficient sureties for the due carrying out of the work. The tender of the Stanley Coal and Iron Company for the supply of cast iron pipes for the cables was accepted. Mr. D. Lee was appointed clerk of the works for the supervision of the erection of the new buildings at the generating station.

Electric Pumping Plant.—We understand that Messrs. Ernest Scott and Mountain, of Newcastle-on-Tyne, have contracted with the Lothian Coal Company, Newbattle Collieries, Dalkeith, near Edinburgh, for the supply of two electric pumping plants. The plant will consist of two compound horizontal condensing engines, each engine to be capable of giving 120 effective horse-power. The engines will actuate a main countershaft driving on to two "Tyne" dynamos, each capable of giving an output of 60,000 watts, and requiring 100 effective horse-power to drive. The current from these dynamos will be taken by two pairs of armoured cables to the pumps, which are placed at the bottom of the pit, and each set of pumps will be capable of delivering 200 gallons of water per minute against a head of 600ft., the pumps being driven by "Tyne" electric motors, each capable of giving 60 effective horse-power. The pumps will be of the three-throw ram type, the rams being 7½in. diameter by 12in. stroke, and the general design of the pumps will be in accordance with Messrs. Scott and Mountain's latest practice in this class of machinery, the pumps all being independent, with independent valve-boxes, thus providing against any possible breakage of either of the pumps or valve-boxes. The same firm are just completing, as mentioned in our issue of the 22nd ult., for the Shilbottle Coal Company a set of three-throw pumps capable of delivering 200 gallons of water per minute against a head of 200ft. In addition to this the firm supplied about 12 months since to the North Seaton Colliery a set of three-throw ram pumps capable of delivering 300 gallons of water per minute. These pumps have run during that period practically day and night, and have given satisfaction to the directors and officials of the Cowpen Coal Company.

Electric Lighting at Peterborough.—A special meeting of the Peterborough Town Council was held on Thursday of last week to decide whether an application should be made by the Council to the Board of Trade for a provisional order to supply electricity. The Mayor (Councillor J. Clifton) presided. For the information of the Council the borough engineer, Mr. Gill, had prepared a printed report, which we published in our last issue, and in which he recommended the Council to adopt a central station at an estimated cost of £12,500. A deputation, consisting of Messrs. W. Clarabut, G. W. Holden, and Webb, waited on the Council. Mr. Clarabut handed in a petition signed by about 140 ratepayers in favour of the electric light, and asking the Council to adopt it, reminding them that there were very few towns of this size which had not electric supply stations at work. Mr. Holden said he was very proud to support the petition, which was signed by two-thirds of the principal merchants and traders in the city, who believed the electric light could be adopted with profit by the Corporation. Councillor Miller said he was given to understand many people signed the petition under the impression that the electric light was cheaper than gas. Mr. Holden said this was not so. In reply to the Mayor, the Borough Engineer said he did not think there would be any difficulty in getting people to take the number of lights that would be required to warrant the success of a central installation. Councillor Simpson asked the memorialists if they were prepared to take the electric lighting in hand in the event of the Council refusing. Mr. Clarabut said he believed a company were prepared to take the matter up in such a case. The deputation having withdrawn, the Council proceeded to discuss the matter. Councillor J. Hunting proposed that the Corporation apply for a provisional order. He said by so doing the Corporation would be only following the example of other enterprising towns. It could not be denied that electricity was the light of the future, and they, as a corporation, had no right to adopt a dog in the manger policy, and to shilly-shally with the matter. Let them say once for all "we will apply for powers to do the lighting ourselves or allow others to do it for us." Looking at in a business point of view, and as the Corporation of an enterprising town, he hoped they would give the ratepayers the same opportunity they had in smaller towns of having the electric light. Councillor Nichols seconded, remarking that he did not think it was a speculative matter, and from the petition they might fairly judge that there would be sufficient consumers to guarantee its financial success. Councillor Miller moved a direct negative, remarking that he opposed the matter on purely financial grounds. He quoted figures in support of his argument that gas was a cheaper illuminant than electricity. Mr. Miller said that if the money mentioned by the engineer was expended it would leave but a very small margin under their borrowing powers to provide for any serious contingency that might arise in respect to the water supply or other important matters. He appealed to the Council to wait until other people had tried the experiment. The Engineer defended his figures, and stated, as a contradiction to Mr. Miller, that wherever electric lighting had been undertaken by municipal authorities it had been a financial success. Alderman Redhead seconded the amendment, and after some further discussion it was rejected and the original motion carried.

Edinburgh and the Electric Light.—Under this title Mr. A. B. Brown, of the Rosebank Ironworks, Edinburgh, writes to the *Scotsman* in reference to the report prepared by Prof. Kennedy, and which is given in another column. Mr. Brown says: "It seems to me that the Gas Commission (a body elected by the ratepayers, have not given the subject of a supply of cheap gas that consideration with the Electric Light Committee (also representing the ratepayers, which it deserves. The interests of these parties are identical, representing as they do each in their own department the interests of the ratepayer, and how the Gas Commission can supply gas at cost price for street lamps and decline to give it for other public purposes as electric supply in large quantities at such a wholesale price I fail to see. It is obvious in this electric lighting scheme that every 8-c.p. lamp will displace an eight candle burner of gas, and therefore the Gas Corporation ought to seriously consider the question of reducing the price of their gas for a large account to the Electric Committee of the Town Council to the lowest possible price, seeing that there would not be anything like the expenses of either distribution with its attendant leakages, or the collection of numerous small sums which obtains with small consumers. If the Gas Commission would only see their way to this, Prof. Kennedy's scheme would be very much simplified, inasmuch as he could use gas engines—which have now been undoubtedly proved to be much more economical than the best steam engines he is in the habit of using—with gas such as is now used in Edinburgh if supplied at 2s. 6d. per 1,000ft. For instance, no boilers are required, and consequently no stokers, no coal to be delivered and ashes carted away, no chimney-stalk, and therefore no smoke nuisances. Another important advantage is (and Prof. Kennedy knows this well) that while the best triple-expansion engine works at half load, it is a most inefficient machine; while, on the contrary, gas engines of very large power can be run at quarter or half power with practically the same efficiency as at full load. This is clearly shown in the case of the Glasgow electric lighting scheme, where Prof. Kennedy puts down the triple expansion engines in multiple; and in the case of Edinburgh, with 1,500 h.p. as proposed, he would in all probability have at least 10 sets of engines. Now, assuming the fact that the gas-engine of the present day is much more economical than the best steam-engine, then the door is opened up to the installation of the electric light in Edinburgh by numerous sub-stations, which at once relieves Prof. Kennedy from his project for the south side of a high-tension alternating system with its sub-stations of transformers with necessary attendance, and it would also dispense with a large number of the copper feeders in the northern section, due to the fact that gas-engines of moderate size could be placed close to their work. The obvious advantage, if the Gas Commissioners would work in harmony with the Electric Light Committee of the Town Council, would be this—that whatever gas lights were displaced by the electric light system, they would be compensated for by the sale of their gas, and therefore the current expenses of the gasworks by any diminution of sales would not be increased, assuming that they (the Gas Commission) are not selling their gas for street lighting under cost price. It must also be remembered by the Gas Commissioners that they, in the process of manufacture, recover the residual products—viz., tar and ammonia—

which, in the working of a steam electric lighting station, would be sent up the chimney as noxious vapours and smoke. In my former letter I did not suggest the use of illuminating gas for driving gas engines, but the manufacture of 'producer' gas from coke which is in use at the Edinburgh Gasworks. This can be made at the works at a cost of less than 2d. per thousand cubic feet, but it would be necessary to lay special mains to convey such gas, which would also be largely used for various motive power purposes. As this gas has only one fourth or one fifth of the power of the illuminating gas, it has been suggested that large mains would be required for its conveyance, but that has been on the assumption that it is to be delivered at the very low pressure of illuminating gas, which, of course, is quite absurd. With gas engines which use the gas under compression this 'producer' gas could be delivered through very small pipes at, say, 20in. water pressure, at a very small expenditure of power and at high velocity by means of a fan or equivalent blowing engines. The cost of laying these pipes of small diameter would not be anything like so expensive as the long feeders of copper proposed by Prof. Kennedy. In London the city is completely traversed by a network of pipes conveying water at a pressure of 750lb. per square inch, and Glasgow is following the example for general power purposes. With reference to Prof. Kennedy's report, there can be no objection to the electrical part, excepting the alternating high tension current system, which would disappear with the use of gas. But a grave objection in the report consists in the centralisation of the whole machinery in one centre, involving the burying of thousands of pounds as copper conductors in the ground, and also his settling a price per unit in common for both shops and dwelling houses, as well as his selection as to the districts to be traversed by his electrical feeders. Finally, I strongly advise the Town Council not to be rushed into this project, and on no account to spend this £80,000 on one station; much better spend a few hundred pounds on further investigation, as in any case they cannot possibly light the city this winter, and there is plenty of time for next, particularly if they adopt gas-engines. I am prepared to support this advice, having only a few days ago seen a compound gas engine at work of 600 h.p. near Glasgow, which is designed to produce the electric light so far as Edinburgh gas is concerned at 1¼d. per unit. I have myself had a small station of 30 lights fitted in my house in Douglas crescent for five years, consisting of a gas engine, with gas at 4s. per 1,000ft., and secondary batteries, which has been run at a cost of 1¼d. per unit, and allowing for the interest and deterioration on the plant and attendance, the cost does not exceed 3d. per unit. The reason, of course, is that there are no long copper conductors, which for the most part would be half idle in a scheme where the electrical energy emanated from one centre. The proposal, therefore, to charge 6d. per unit on such a large scale is due entirely to a large amount of sunk capital buried in the streets; and it is not likely that particularly large installations, such as hotels and theatres, will avail themselves of the supply under these circumstances."

PROVISIONAL PATENTS, 1893.

SEPTEMBER 29.

23101A. '92. **Improved methods of recovering zinc from the waste products of galvanic batteries.** Carl Anton Johannes Hugo Schroeder and Heinrich Eugen Richard Schroeder, Whetstone House, Heslop road, Balham, London. (Date claimed under Patents Rule 19, December 15, 1892.)

23101B. '92. **New or improved galvanic batteries.** Carl Anton Johannes Hugo Schroeder and Heinrich Eugen Richard Schroeder, Whetstone House, Heslop road, Balham, London. (Date claimed under Patents Rule 19, December 15, 1892.)

SEPTEMBER 25.

17972. **Improvements in make and break contacts for electric bells, fire and burglar alarms and other purposes.** Arthur Mills, 62, Great Percy street, Amwell street, Clerkenwell, London.

17980. **Improved process and means used therein for the electrolytical production of gases.** Percy Beresford Wright Kershaw, 1, Queen Victoria street, London.

17981. **A magneto-electrical igniting apparatus.** Julius Drach, 28, Southampton buildings, Chancery lane, London.

17992. **An improved composition and the production therefrom of blocks, slabs, tubes, vessels or like articles, more especially intended for the production of paving blocks or slabs, or conduits for electric cables.** Carl Jost, 47, Lincoln's inn fields, London.

SEPTEMBER 26.

18019. **Improvements in electrical switches.** John Henry Tucker, 40, Charles road, Birmingham.

18058. **Improvements in microphones.** Sir Charles Stewart Forbes, Bart., 21, Finsbury pavement, London.

18064. **Improvements in electric switches.** The Edison and Swan United Electric Light Company, Limited, and Philip Henry Bell, 28, Southampton buildings, Chancery lane, London. (Complete specification.)

18066. **Improvements in and appertaining to adjustable supporters for electric lamps and other objects or articles.** William Robert Lake, 45, Southampton buildings, Chancery lane, London. Otis Converse White, *United States.) (Complete specification.)*

18069. **An improved form of electrical switch.** William Henry Sharpless, 608A, Old Ford road, London.

SEPTEMBER 27.

18115. **A new or improved electric arc lamp specially applicable for projecting purposes instead of the limelight.** Frederick John Borland, 8, Quality court, Chancery lane, London.

18117. **Improvements in brush-holders for dynamo-electric machines and electric motors.** Horace Ingram and Alfred Ingram, 40, Durham road, Seaforth, Liverpool.

18150. **A portable secondary battery lamp for use in mines and other places.** Villeroy Corney Doubleday, 77, Chancery lane, London. Max Sussmann, Germany.)

18165. **Improvements in and connected with electric switches for series circuits.** Albert Augustus Goldston, 4, South street, Finsbury, London.

18170. **Improvements in electrical contacts.** John Smith Raworth, 46, Lincoln's inn fields, London. (Complete specification.)

18173. **Improvements in apparatus for the electrolysis of chlorides and other salts.** James Hargreaves and Thomas Bird, 191, Fleet street, London.

18175. **Improvements in switchboards for telephone exchanges.** Oswald Franz and Gustav Otto, Norfolk House, Norfolk street, London. (Complete specification.)

SEPTEMBER 28.

18188. **Improvements in or relating to electric telephones.** Thomas Sloper, 14, Britton, Devizes.

SEPTEMBER 29.

18291. **Improvements in or appertaining to submarine telegraph and like cables.** Herbert Arnaud Taylor and Joseph Arthur Lovel Dearlove, 124, Chancery lane, London.

18323. **Improvements in electric batteries.** Henry Harrington Leigh, 22, Southampton buildings, Chancery lane, London. Auguste Chevallier, France.) (Complete specification.)

SEPTEMBER 30.

18346. **Improvements in electric switches.** Edwin William Percy Cummins, Cobden buildings, Corporation street, Birmingham.

18375. **Improvements in or relating to the arrangement of electrical circuits and switches.** Joseph Arthur Montealegre, 19, Southampton buildings, Chancery lane, London.

SPECIFICATIONS PUBLISHED.

1892.

14124. **Electromotors.** Hurd.
14239. **Electricity motors.** Hookham.
16300. **Electrolysis of fused electrolytes.** Frei.
16335B. **Magneto-electric generators.** Harrison.
16335C. **Electric bells.** Harrison.
17091. **Insulating and supporting electric wires, etc.** Crompton and Dowsing.
17099. **Carbon electrodes.** Barnett.
17877. **Dynamo-electric machines.** Andrews and Preece.
17878. **Starting electric motors.** Andrews and Preece.
17909. **Electric switches.** Challis.
19953. **Electrodes.** Richardson.
20348. **Electric battery cell.** Black.
20418. **Magnetic water gauges.** Kleritj.

1893.

11069. **Telegraph wires, rails, pipes, etc.** Thompson. (Ries and another.)
11077. **Electric circuits.** Peterson.
14910. **Electrolytical decomposition.** Jensen. (Sinding Larsen.)
15110. **Electromotors.** Perret.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid	Price Wednesday
Brush Co.	-	3
— Pref.	—	2¼
Charing Cross and Strand	-	6
City of London	-	11½
— Pref.	-	12¾
Electric Construction	—	—
House to House	5	5¼
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¼
London Electric Supply	5	1
Metropolitan Electric Supply	-	7
National Telephone	-	1½
St. James', Pref.	-	8½
Swan United	3½	3⅝
Westminster Electric	—	5¼

NOTES.

St. Pancras.—Complaints are made of defective arc lighting of Camden-road, N.W.

Christiania.—The work of constructing an electric tramway is being carried on speedily.

School of Shorthand.—The Metropolitan School of Shorthand is now lighted by electricity.

Derby.—As described in another column, the central station was started on Tuesday evening.

Goole.—It is suggested that it would be wise policy for the Local Board to formally adopt the Electric Lighting Act.

Personal.—On Tuesday Lord Kelvin was present at a sitting of the French Academy of Sciences, when he read a paper.

Junior Engineering Society.—The annual general meeting took place last Friday at the Westminster Palace Hotel.

Newport Tramways.—The Corporation have decided to extend the tramways to the eastern district of the borough.

Madras.—The engineer of the Madras Railway is preparing plans and estimates for lighting Arkonam Station by electricity.

Bradford.—A paper on central-station systems of lighting is to be read before the Bradford Scientific Association.

Erratum.—In the review given in our last issue of "The Dynamo," read $\frac{1}{\mu}$ instead of μ.

Long-Distance Telephony.—A metallic circuit telephone system is about to be set in operation between Berlin and Cologne, a distance of 392 miles.

Insulation Resistance.—Dr. Hein, of Hanover, has devised a method of testing the insulation resistance of non-conductors surrounding electric light conductors in ordinary installations.

San Francisco.—Two months after the closing of the Chicago Exhibition, which event will take place at the end of this month, another exhibition will be held at San Francisco, in California.

Blackpool.—The municipal electricity works will be inaugurated to-morrow by Lord Kelvin, in the presence of the mayor, the chairman of the Electric Lighting Committee, and a number of invited guests.

Bolton.—Alderman Dobson, when the question of the tramways was considered last week, mentioned that the trolley system which he had seen in America was "most dangerous." Evidently Mr. Dobson has been very much misinformed on the matter.

The Transcontinental Telegraph.—The contractors for the Salisbury-Tete section of the transcontinental telegraph have left Fort Salisbury, and the material for the construction of the telegraph is now being conveyed to that place by the Beira Railway.

Engineers and Shipbuilders.—A conversazione of the North-East Coast Institution of Engineers and Shipbuilders will be held on Tuesday, the 24th inst., in the Westgate-road Assembly Rooms, Newcastle-upon-Tyne, to open the tenth session of the institution.

The County Council.—The Highways Committee have been instructed to consider how far the proposed agreement about to be made between the National Telephone Corporation and the postal authorities would affect the Council's position in regard to the telephone service in London.

Standard Sizes of Screws.—The Union of German Electrical Engineers have appointed a committee to report on the introduction of a standard size for contacts and screws used in appliances accessory to electric lighting, as, for instance, switches, safety fuses, and large instruments dealing with up to 1,000 amperes.

The Metric System.—As an indication of the growing favour of the metric weights and measures in the United States, it is interesting to note that at a meeting of the Board of Managers of Engineering Societies recently held in Chicago, it was resolved that illustrations to be drawn to scale should bear the metric scales.

Frankfort Exhibition.—Two years have elapsed since the holding of the International Electrical Exhibition in Frankfort, and although various tests were made of boilers, engines, and dynamos, the official statement of results has not yet been published. This delay is now to form the basis of an action by one of the exhibitors.

Electric Heating of Metals.—In previous issues reference has been made to the Lagrange and Hoho system of heating metals sufficiently to allow of their being welded. This method was described recently by Mr. Ross at a meeting of the Union of German Electrical Engineers, and was also demonstrated at the Hagen accumulator works.

Locomotion in London.—The Public Health and Housing Committee of the London County Council are to be requested to provide the best means of acquiring information on the question of locomotion in London, including railways, tramways, omnibuses, and steamboats. It is possible that prizes will be offered for essays on the subject.

Iron and Steel Tubes.—We have received a copy of a new and revised edition of the catalogue issued by Mr. John Spencer, manufacturer of iron and steel tubes, of the Globe Tube Works, Wednesbury. The firm make all kinds of iron and steel tubes and fittings, including wire and cable tubes for electrical purposes, telegraph poles, bases, etc.

The Halle Tramway.—The Halle Tramway Company propose to acquire for £40,000 the electric tramway worked in this town by the General Electricity Company of Berlin. The transfer would comprise the rolling-stock and the generating plant, the lines and the depôt belonging to the town. It is intended to substitute electric traction for the system now used on the other tramways in Halle.

Shiplighting.—Opportunity is being taken in Chatham Dockyard to improve the electric lighting arrangements of of whole of the first-class armoured battleships fitting and preparing for sea. The electric lighting of the ships is being taken in hand by private electrical engineering firms, the battleship "Howe" being already completed. New electric lighting apparatus will also be fitted to the battleships "Monarch" and "Agincourt."

Hard Fibre.—We have received samples of hard fibre from the Delaware Hard Fibre Company, of Wilmington, Del., U.S.A., whose European agent is Mr. J. Burns, of 15, Long-lane, London, E.C. This fibre is made in sheets, tubing, rods, washers, bushings, and special shapes. The makers state that this fibre is specially adapted for insulating purposes, for thrust bearings, pump valves, rollers, etc., and that it is unaffected by oil.

Traction at Cardiff.—As mentioned in our issue of the 29th ult., the question of municipalising the tramways has been under consideration. When the subject was discussed on Monday by the County Council, Alderman Carey pointed out the possibility of electricity being used as the motive power in connection with the tramcars. It was

ultimately resolved to appoint a committee to report on the subject of acquiring the tramway system.

Traction at Bordeaux.—An electric tramway, just over three miles long, is being constructed at Bordeaux on the Thomson-Houston system. The line is almost level, there being practically no gradients. Six cars will at first be put into service. The generating station contains Babcock and Wilcox boilers, and two steam-engines of 150 h.p. which drive four-pole compound Thomson-Houston dynamos of 100 kilowatts, the pressure being 500 volts.

Tape Instruments.—A petition has been signed by brokers and jobbers in the Stock Exchange asking the committee to use their influence with the directors of the Exchange Telegraph Company to limit the supply of their tape machines to members of the house and to such banks, newspapers, offices, and institutions as the committee may be satisfied will not attempt to use the information supplied for the purposes of dealing. Although this movement has not arisen from disinterestedness, it is a step in the right direction, but it is doubtful whether the desired object will be attained.

Telephony at Devonport. — The Admiralty have decided to establish a telephone exchange at Devonport, which will not only include within its operations all the naval and dockyard establishments in the port, but the breakwater fort in Plymouth Sound, the "Defiance" torpedo school-ship in the St. Germans River, the "Cambridge" gunnery ship, and the "Lion" training ship for boys. The system will also include a private wire embracing the whole of Devon and Cornwall, going as far seaward as Rame Head. The work has already commenced, and when completed the exchange will be the largest and most extensive that the Government have in any port in England.

Lighting of Tramcars.—The electrical engineer to the Glasgow Corporation, Mr. W. Arnot, has been investigating the merits of various batteries for the lighting of omnibuses and tramcars. The Tramways Committee of the Corporation have been authorised to ask Mr. Arnot to submit a statement showing the price at which electric energy could be supplied to batteries for the electric lighting of the tramcars, and also the cost of laying down and superintending the dynamos and other plant required for charging the batteries from five of the car depôts now being erected by the Corporation. It is is very probable that all the tramcars in Glasgow will be lighted electrically.

Submarine Torpedo Boats.—A new type of submarine torpedo boat has been built for the United States Government. It is of the ordinary cigar-shaped type, 80ft. long and 11ft. in diameter in the centre, and constructed to descend 70ft. below the surface of the water. Two quadruple-expansion engines, developing 1,000 i.h.p., will drive the vessel at 16 knots on the surface, at 15 knots when submerged with only the top of the hull or covering tower above water, and it is expected at eight knots when under water. When submerged the ordinary steam-boilers will be closed air and water tight, and the motive power provided by electric storage batteries sufficient to run the vessel for six hours under water, whilst coal will be carried for 15 hours' run on the surface.

Brake Failures.—It appears that accidents due to brake failures frequently occur on the Cincinnati electric car lines. On September 9 a car burned out its fuse wire while climbing a steep grade, and began to back down the hill. The brakes were applied, and were in good order, but the grade was so steep that the car attained high speed with the wheel sliding on the rails. The conductor and motor-man of a car which was following saw the other car coming, stopped their own car, ran ahead of it, and threw some planks across the rails, which finally brought the runaway to a standstill. Another car, on the East End electric line, in Cincinnati, broke its brake rigging on September 4, while descending a grade. It attained so high a speed that it finally left the rails on a straight track, struck a car on a switch track a glancing blow, and after running some distance over the granite pavement brought up against the kerb.

A Great Lighting Scheme.—A Greek engineer is said to have just elaborated a great project of lighting by means of the electric light the whole of Constantinople, all the Bosphorus, from Cavak as far as the historical village of San Stefano, upon the Sea of Marmora, by means of three very powerful generators to be erected upon the three points of the Bosphorus where the current has an extraordinary force—that is to say, at Arnaout-Keui, Candilly, and at Serai Bournou, at the entry of the coast port of the Sea of Marmora. The project has appeared to be so practical and realisable that a company of capitalists has been formed, the necessary funds subscribed, and a demand for a concession has been addressed to the Turkish Government. The latter, on the other hand, has taken the project into serious consideration, and, without losing time, has nominated a commission *ad hoc* to examine the details and draw up an official detailed report.

Cheap Current.—Writing on central stations in the columns of an evening paper, "M. B. C." says: "At present the demand is low, and the hours during which electric light is used are short, because present charges are so high that consumers must needs be economical. But when more people want electric light, and use it for longer hours, it will pay supply companies to establish lower rates just the same as it paid the Post Office to institute a penny post. In fact, to such an extent is this law of increased demand cheapening supply true in electrical affairs, that if there were sufficient demand to warrant a supply station running its machinery at full load 24 hours every day, electricity could be on sale at a farthing per unit instead of 7d.—a price for illumination comparing with gas at 2d. per 1,000ft." We do not know who "M. B. C." is, but he makes a very rash and questionable statement that electrical energy could be sold at a farthing per unit with a full load throughout the 24 hours.

Train-Lighting.—It is stated that the second week in November will witness the introduction of automatic electric reading lamps in some of the trains on the District Railway, and to which reference was made in a previous issue. Although this is not altogether a novelty, it will be the first permanent installation of the kind, and 2,500 lamps will be fixed in the carriages during November by the Railway Automatic Electric Light Syndicate, the previous experiments having given satisfaction. The lamp is an ingenious contrivance by means of which passengers can obtain half an hour's light for a penny. The coin, on being dropped into the machine, winds a small clock which switches on the current, and a light is produced. One battery in each carriage supplies the four lamps in each compartment. The lens attached to the lamp is sufficiently convex to concentrate the rays of light upon the paper or book of the passenger immediately beneath it. If the door of the lamp is tampered with the offender is detected, for directly it is opened a bell is rung in the guard's van.

The City Telephone Tubes.—A somewhat animated discussion took place on Tuesday at a meeting of the City Commissioners of Sewers, on the subject of the telephone tubes of the City of London Electric Lighting Company. Mr. J. Harris said it was rumoured that the company were

using the telephone tubes without the consent of the Commission, and he moved that the matter should be referred to the Streets Committee to enquire and report. Mr. Morton, M.P., urged that a strict and full enquiry should be made as to how the tubes were allowed to be put down at the same time as the electric light conduits without the knowledge and approval of the Court. Mr. Ross, the acting engineer, said that all the tubes were on the plans deposited with the Commission, but there was no indication that they were to be used for telephonic purposes. Mr. Deputy Scott, who was chairman of the Commission at the time, said he was fully aware that the telephone tubes were to be inserted simultaneously with the electric light tubes, and he considered the operation was of distinct public advantage. Mr. Berridge said the telephone tubes had been laid surreptitiously, and the Court had been hoodwinked in the matter. Mr. Morton submitted that now the electric lighting company were attempting to sell the telephonic tubes to another company. It was only when the company found that the tubes could not be used without the consent of the Commission that what had been done leaked out. It was ultimately decided to refer the matter to the Streets Committee to enquire and report upon.

Electric Light and Power at Railway Stations. The contract for an important installation of electrical plant for lighting and power purposes has just been obtained by Messrs. Westinghouse, Church, Kerr, and Co., the well-known American engineering firm. The plant represents an aggregate capacity of 1,100 h.p. in the engine-room, with corresponding equipment throughout, and is to be employed for the electric lights and motors at the new railway station now being built in Boston, U.S.A., for the Boston and Maine Railroad. Four Westinghouse dynamo generators are to be installed, coupled direct to Westinghouse vertical compound condensing steam-engines of 200 h.p. each. Two of these generators will supply current for 4,000 incandescent lights for the interior of the station, platforms, offices, etc.; the other two furnish power to a number of motors operating drawbridges, turntables, elevators, coal hoists, etc. Besides these there are two other compound engines respectively of 200 h.p. and 100 h.p. each, driving alternate-current machines for lighting purposes at stations outside the terminal depôt, and situated respectively one and two miles out. They also serve to supply current for lamps along the line, used for signalling, etc., and in the signal cabins too. Each of these engines exhausts into an independent surface condenser using salt water—the station being close alongside a sea-wharf. The boilers are of the horizontal return-tube type, 12 in number, the steam pressure being 125lb. A novel feature in the station design—so far at least as English engineering practice is concerned—is the employment of forced draught for the boilers. The chimney stack is made of steel plates riveted together, and rising only to a height of 55ft. above the ground level. Two large fans, each driven by a small independent engine, supply the draught, and either set is capable of the full service. The subsoil in this locality being extremely soft—almost mud, in fact—the advantage of doing away with a tall brick or masonry chimney stack based upon an expensive pile foundation, is too obvious to need emphasising.

Tramway Provisional Orders.—Whilst not being purely electrical, it may be interesting to refer to the proceedings of the Board of Trade under the Tramways Act, 1870, during the 1893 session. The number of applications to that Department for provisional orders under the Act, made in December, 1892, was seven—viz., Birmingham Central (cable), Blackpool Corporation, Great Yarmouth, Hull, Manchester Corporation, Plymouth Corporation, and South Staffordshire. All these applications proposed the construction of new tramways, being in every case, except Great Yarmouth, in extension of, or in substitution for, lines already in use. The aggregate length of new tramway was 14 miles 9 chains of double line, and 8 miles 69 chains of single line, the total estimated cost of construction being £173,121. The Birmingham Central, Hull, and South Staffordshire applications were ultimately dropped by the promoters. Four provisional orders were granted by the Board of Trade—viz., Blackpool Corporation, Great Yarmouth, Manchester Corporation, and Plymouth Corporation. The Blackpool and Plymouth orders empowered the Board of Trade to grant a license enabling the local authorities to work the tramways on being satisfied that the lines could not be leased at an adequate rent. In the case of the Great Yarmouth order, the deposit money not having been paid into court, the Board of Trade were unable to submit the order to Parliament for confirmation. A Bill to confirm the other three provisional orders was introduced in the House of Commons on May 5th. Petitions were presented against the Blackpool and Plymouth orders, but were subsequently withdrawn, and the Bill passed through the first House unopposed. In the House of Lords petitions were again presented against the Blackpool order by the promoters of the Blackpool, St. Annes, and Lytham Tramways Bill, and against the Plymouth order by the National Telephone Company, Limited. New clauses and other amendments were agreed upon between the parties, and the Bill received the Royal assent on August 24th. The form of protective clause recommended by the Joint Committee on Electric Powers was, with slight modifications, incorporated in the Blackpool and Plymouth orders in lieu of clauses previously inserted.

Electric Light versus Gas.—Comparisons of these illuminants are becoming somewhat wearisome. Mr. D. Terrace, the engineer and manager of the Middlesbrough Gasworks, dealt with the subject in his presidential address delivered last Saturday before a meeting of the North of England Association of Gas Managers. He said: "I should like to reiterate, however, in as clear a manner as possible, the relationship in the cost of the rival lights to the consumer—*i.e.*, light for light. This has hitherto been stated more or less clearly, and sometimes with a certain vagueness on account of the technicality of the subject." The president then gives a comparative table, and says: "It is thus that electricians compute (the 3s. 10d. against the 3s.) the cost of their light being 'cheaper than gas.' Their assumption of six units instead of 10 units, allowed by the Board of Trade as being equal to 1,000 cubic feet of gas, is a wilful playing with 'standards of light.' It is, however, done with the greatest *sang froid*. Were the gas industry to be as guilty of misrepresentation, it could with all reason adduce the latest development in economical lighting by gas—viz., the incandescent light, which reduces the cost to one-sixth of our standard, or one-fifteenth of the cost of electric light. The fair way to put it, however, is: gas standard, 2s.; electric light standard, 5s.—*i.e.*, electric light two and a half times the cost of gas, light for light." The latter seems to be a very fair statement, but we are surprised that Mr. Terrace lays stress upon or even takes any serious notice of what he terms the assertions of "one-sided advocates." The president states further that "there are about 600 towns which may be expected to use the electric light, if it were a success commercially; but only 5 per cent. of these as yet have each a comparatively small installation." Surely Mr. Terrace betrays gross ignorance on this point. Has he never

heard of dividends being paid out of net receipts by different electric light companies? He is also evidently unacquainted with the present position of electric lighting, otherwise he would not say that "as the number of towns experimenting with the new light is in a decreasing ratio, this shows that it has reached its level, and that it now appears in its proper guise in the estimation of those who may adopt it, if not in that of the electrician and capitalist." It is a pity that a gas advocate should distort facts in this manner. Mr. Terrace evidently does not read the *Electrical Engineer* or any other electrical journal, or he would be aware of the fact that the number of towns experimenting with the new light is in an increasing ratio.

Traction at Glasgow.—As our readers are doubtless aware, the Glasgow tramways become the property of the Corporation in July of next year, and in view of this fact the Tramway Committee are carrying out extensive arrangements for undertaking the traffic on the 1st of that month. It is intended that the new service shall from the beginning be complete in every detail, and after careful consideration the committee decided to erect no less than nine extensive depôts in various districts of the city, and sites for these were secured. At each of the depôts car-sheds, stables, and loose-boxes, with shoeing forge and other necessary appurtenances, are in course of erection. In addition to the usual accommodation for horses and cars, workshops for car building and repairing are being erected at Coplawhill. The buildings—which are roughly estimated to cost about £100,000—will afford accommodation for about 3,000 horses and from 250 to 300 cars and other vehicles. All, or nearly all, the cars for the service are now being built according to the design of the pattern car exhibited some time ago and approved of by the Town Council. While all that is being done points to horse traction to begin with, the buildings are so arranged as to admit of adaptation for other motors at the least possible expense, and the committee are carefully studying every system of mechanical haulage which is available, or likely to be available, for street tramway purposes, and they hope that before long, if not at the beginning of the Corporation service, mechanical traction will to some extent supersede horses on the Glasgow tramways. Extensions of the tramway system have been decided upon to improve the service, and there is every indication that the municipal tramways will be inaugurated with success. In connection with this important part of Corporation work an interesting ceremony took place the other day, when the memorial stone of the Coplawhill depôt, which is the most extensive of the stations, was laid by Lord Provost Bell. The Lord Provost said that the cars (as mentioned in another column) would be lighted with electric lamps, so that a person might read his paper on his way home. Altogether he thought they could promise that the service would be superior to the car service of any other city in the world. Bailie Paton mentioned that the Tramway Committee had had a very large amount of work to do. The buildings had been constructed so that should horse haulage be superseded they could, without difficulty, be adapted for the accommodation of mechanical motors. With regard to the question of motors, he stated that the tramway department was extremely anxious, even at the beginning of the work, that they should be able to open some routes with other motors than that of horse haulage. Whether they might succeed in that or not he could not exactly say at present, but he could give the assurance that they were not without hope that on some of the routes, at least, they might be able to accomplish that purpose. He said that great credit was due to Mr. John Young, the general manager, and his able assistant, Mr. Clark, for the manner in which they had carried out the design of the various buildings, and he believed that by the time the whole work was accomplished they would find that their capital account, upon the whole, would compare extremely favourably with that of the Glasgow Tramway Company, and would be a great deal less than that of other tramway companies throughout the country.

A New Storage Battery.—A new type of storage battery has been designed by Mr. N. Wladimiroff, an ex-lieutenant of the Russian Imperial Guard. Its construction involves several points of interest. The battery being intended specially for portable work—such as boats, train and carriage lighting, etc.—lightness was a first consideration, but at the same time attention has also been given to the other details, such as freedom from spilling of acid, indestructibility of the containing-vessel, etc. We may premise, says the New York *Electrical Engineer*, in describing this battery, that the battery is of the series type, in which one side of each plate constitutes a positive and the other a negative element, the plate itself acting as the necessary partition. A series of the plates is ranged side by side to form the cell. The lead plates, whose diameter varies, of course, with the capacity of the cells, consists of a central sheet, cast with a thin spiral web on each side. The trough or groove between the spiral webbing is filled with the active material. After the plates have been thus filled, they are assembled by clamping them between a series of hard rubber rings, which bear against the outer circumference of the plates. These rings have a thin rib running for a short distance along their lower end to catch any active material that may drop from the cells and prevent it from short-circuting the plates; rubber washers between the rings also aid to keep the cells acid-tight, the rings being grooved for that purpose. The insulating rings and the plates alternate and the space between them is filled with acid, which is poured in through a small opening at the top of each ring. In the battery exhibited at the Chicago Exhibition, 14 plates are so mounted to form one battery, and the whole is held together by iron bolts. Since each plate is positive on one side and negative on the other, it follows that the E.M.F. of each cell is added to that of the others, so that in this case each battery has an E.M.F. of over 28 volts. Each of these batteries weighs about 180lb. It may be interesting to cite the results obtained by the officers of the Russian Torpedo School last February, and submitted by them to the Chief Torpedo Inspector of the Russian Navy, as follows:

Maximum charging current	10 amperes.
Normal charging current	3 amperes.
Capacity at above current	30 to 33 ampere-hours.
Weight per watt	0·3lb.
Cost per watt	(12 copeks) 3d.
Efficiency	75 to 80 per cent.
International resistance, 14 elements in series......................	0·136 to 0·19 ohm.
Acid per element.....................	750 to 850 cub. cms.

The report also states that the handling of the Wladimiroff batteries is far easier than that of the type heretofore in use at the torpedo school. The mounting and taking apart of the cells can be readily accomplished, and no leakage takes place. As to the hardiness of the plates, a test was made, first with a current of 80 amperes for 10 minutes, and then with 176 amperes for four minutes. After the discharge had been stopped, the battery quickly reached its previous E.M.F. and capacity. On both these occasions the battery was taken apart and examined, but showed no ill-effects. Similar exacting tests were made by the Testing Committee of the recent Moscow Electrical Exhibition, as a result of which a gold medal was awarded to the inventor.

ELECTRIC SUPPLY COMPANIES.—I.

(Continued from page 271.)

WESTMINSTER ELECTRIC SUPPLY—MILLBANK STREET STATION.

We propose in these descriptions of London central stations to give the details in a form to be easy for reference or comparison. We shall briefly describe the system, give particulars of the station arrangement, generating plant, dynamos, and subsidiary apparatus, dealing in detail with any special peculiarities of plant or station, and more particularly with any recent alterations or extensions.

The Millbank station of the Westminster Electric Light Corporation is situated on the banks of the Thames, somewhat south of the gardens of the Houses of Parliament. It is a very pleasant station to visit, everything is in the strictest working order, quiet, clean, and almost noiseless.

The engineers in charge are: resident engineer, Frank Newington; second, W. Robinson; third, G. Clarke. The working staff consists of 18 men.

SYSTEM.—The distribution is on the continuous-current three-wire system, with a constant pressure of 100 volts at the houses. The supply is continuous, accumulators providing the current required during the early hours of the morning and for the light day load.

The area of supply comprises the Houses of Parliament, which have separate engines, mains, and switchboard; and the surrounding important districts of Westminster, Whitehall, Victoria-street, Great George-street, etc. This area is connected by the network of mains with the company's other central stations at Eccleston-place, Belgravia, and Davies-street, Mayfair.

STATION.—The size of the station is 200ft. by 50ft. It comprises engine-room 57ft. by 35ft., with boiler room behind, abutting on the River Thames, 80ft. by 40ft., accumulator-room above the engine-room, and the same size as this latter, with house, offices, and yard in Millbank-street.

The station is built of brick, the engine-room being lined with white glazed bricks and having a concrete ceiling carried on girders, forming the floor of the accumulator-room. The engine block is of concrete, having a minimum thickness of about 8ft. 6in. A five ton travelling crane is fitted overhead, and the engine-room is ventilated by a 5ft. ventilating fan driven by electric motor. Fire-pipes are fitted in the various departments. The station is lighted by 200-c.p. incandescent lamps, with smaller incandescents at engines and switchboards. The architect of the station was Mr. C. Stanley Peach, of John-street, Adelphi, who designed the buildings to the requirements of the chief engineer, Prof. A. B. W. Kennedy, F.R.S.

BOILERS.—The economical generation of steam power being the first essential to efficient generation of current, the details of the boiler-room should naturally first be mentioned.

There are five Babcock-Wilcox water-tube boilers (nominally 200 h.p. each) each to evaporate 5,000lb. of water per hour, the firing being done by hand. The boilers are fitted with extra steam dome, and have each a grate surface of 30 square feet. The usual working pressure is 150lb. per square inch

The furnace gases pass through a Green's economiser before entering the chimney shaft and heat the feed-water. The feed-pumps and pipes are all in duplicate, and the feed-water is measured continuously through a special meter.

Condensing apparatus is installed, but is not ordinarily in use as yet.

Best Welsh smokeless coal only is used. The coal is brought by barges up the Thames alongside the station. It is lifted by a steam crane from the barges into tipping-trucks on rails. The most careful system of weighing the fuel is adopted. Every truck is weighed by an Avery weighing-machine flush on the track, before the coal is shot into the bunkers, and the coal is again weighed on a smaller weighing machine from the coal-bunkers on to the stoking-floor before being used in the boilers; and a careful record is kept by the men in charge.

There is a complete ring of steam-pipes round the engine-room, connected with duplicate steam-mains from the boilers and having valves so arranged that any engine can be supplied in either of two ways. The pipes are freely suspended from near the roof, and were fitted by Messrs. J. Penn and Sons, Limited. They are steel pipes, 8in. diameter, with copper bends.

ENGINES AND DYNAMOS.—For continuous-current stations the direct-driven high speed steam dynamo practically has ousted other forms in English station practice. In the Millbank-street station the engines are of the well-known Willans high-speed central-valve type, and both compound and triple-expansion machines are used—compound for the smaller dynamos, which supply the Houses of Parliament, and triple-expansion for the larger dynamos for the district supply.

There are four Willans G G compound engines, working up to 90 i.h.p. each, and four triple-expansion engines of the I I type, 200 i.h.p. each—speed, 300 to 350 revolutions. In every case the engine is coupled direct to the dynamo.

The dynamos are eight in number, and comprise two Edison Hopkinson machines, giving 500 amperes at 225 volts; two Goolden dynamos, of the same output; and four smaller Goolden dynamos, giving 400 amperes at 114 volts at a speed of 430 revolutions. The latter machines are used for supplying the Houses of Parliament, or as balancing machines. Copper-gauze dynamo brushes are used.

ACCUMULATORS.—The accumulators—reservoir of energy, or flywheel, so to speak, of the electrical system—form in this station an important adjunct of the generating plant, and are housed in a large and lofty room above the engine-house. They are of the Crompton-Howell type, 500 ampere-hour capacity. There are three batteries, each with a set of 56 cells. One complete set is reserved for the supply of the Houses of Parliament.

The battery-regulating switches are placed in the accumulator-room itself, and are worked from below at the main switchboard by toothed wheel and chain gearing.

SWITCHBOARDS.—There are two switchboards situated one at either end of the engine-house—the smaller for the Houses of Parliament, and the larger for the district supply. These switchboards, built by Messrs. Crompton and Co., are mounted on slate bases, and fitted with complete switching arrangements on both positive and negative mains. Each dynamo has an automatic magnetic main switch for breaking the circuit. The voltage is read continuously by Richard Frères' registering voltmeter. The station log contains complete readings of the other instruments taken every quarter of an hour.

There is an Aron meter in the circuit of each dynamo, so as to record its whole output, and the total readings of these meters are taken to give the total output of the station. Similar meters, but specially made reversible, are used to record the daily charge and discharge of the batteries.

The pilot lines from the feeding points are brought to a multipolar switch connected to a special voltmeter, on which the pressure at the feeding points can then be read off at any moment. The station is connected by telephone to the general offices and other stations of the corporation.

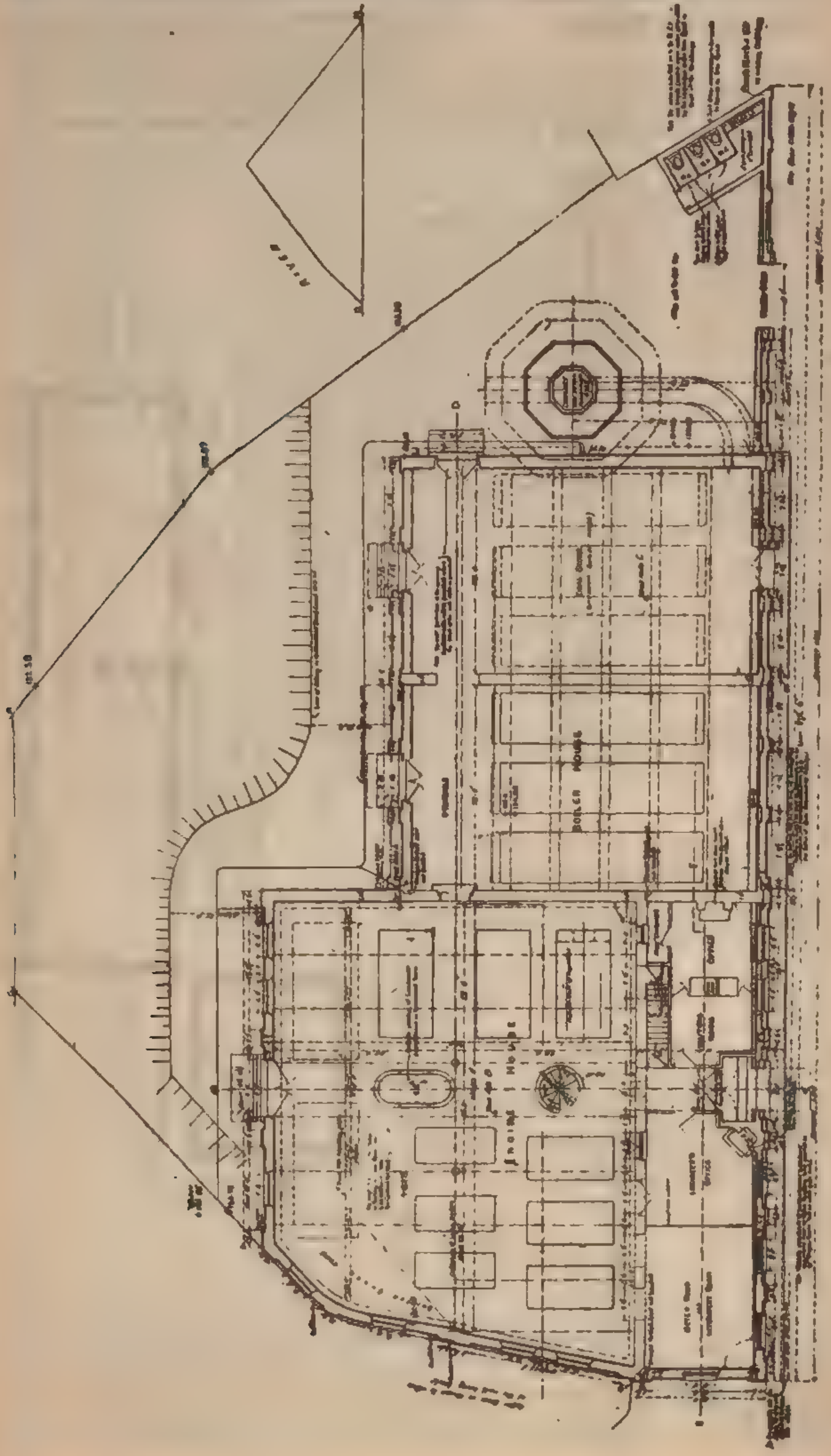
In the resident engineer's office is a complete potentiometer set—Clark cell, mirror galvanometer, potentiometer and shunt box, with secondary cells and standard resistances—used for the checking of all the switchboard instruments and of the dynamo meters.

Every item affecting the cost of generation of current is scrupulously looked after and checked under control of the chief engineer, Prof. Kennedy.

This station—quiet, orderly, with every item thoughtfully arranged—is a model instance in the centre of London; and the extreme constancy of supply forms the best test of working efficiency.

After describing the arrangements in the other two stations of the Westminster Corporation, we shall have, by the kindness of the corporation and Prof. Kennedy, some interesting details to give with reference to the cost of generation of current on the Westminster Corporation's system.

(To be continued.)

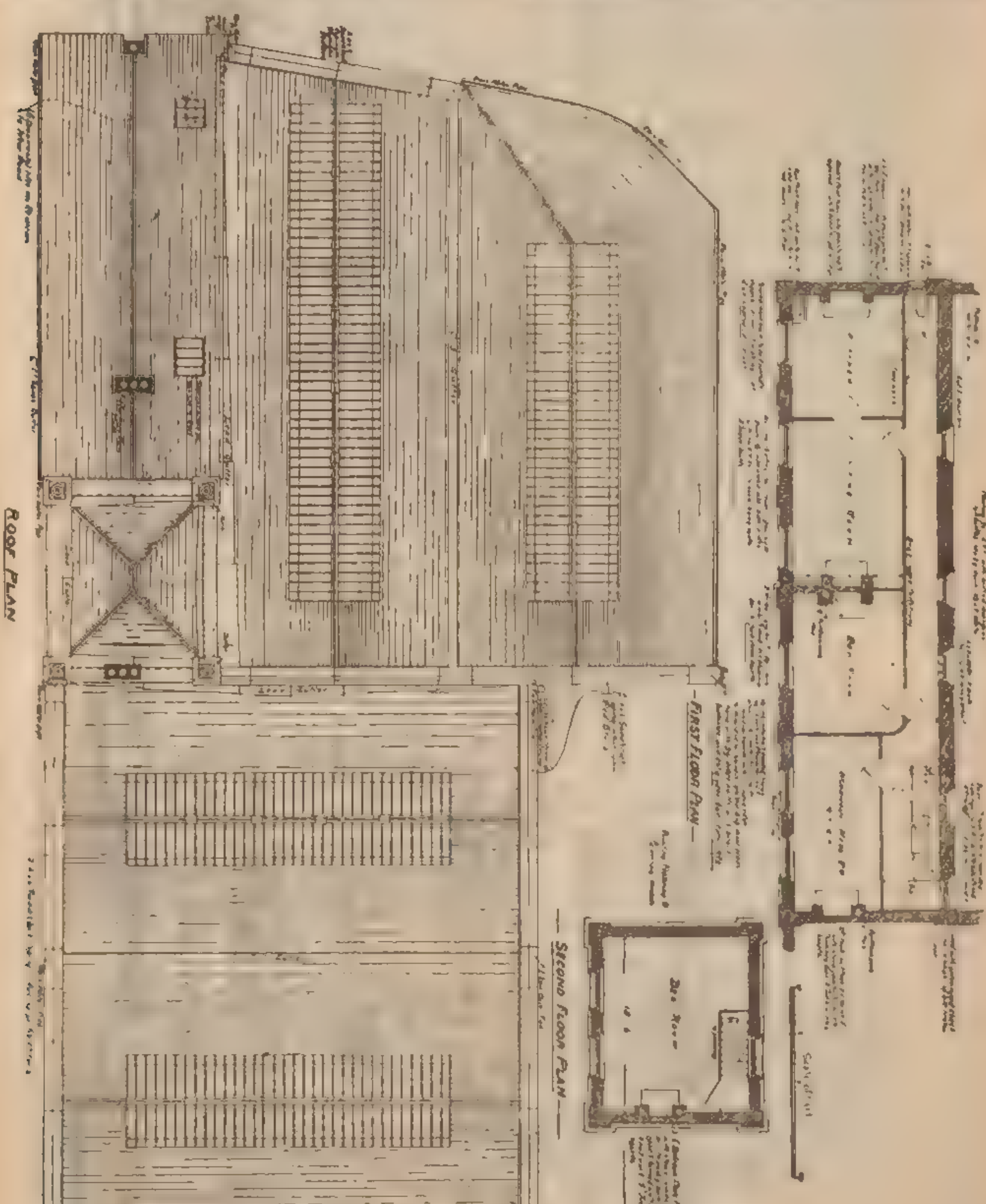


Derby Central Electric Lighting Station.—Plan of Site, showing General Arrangement of Buildings.

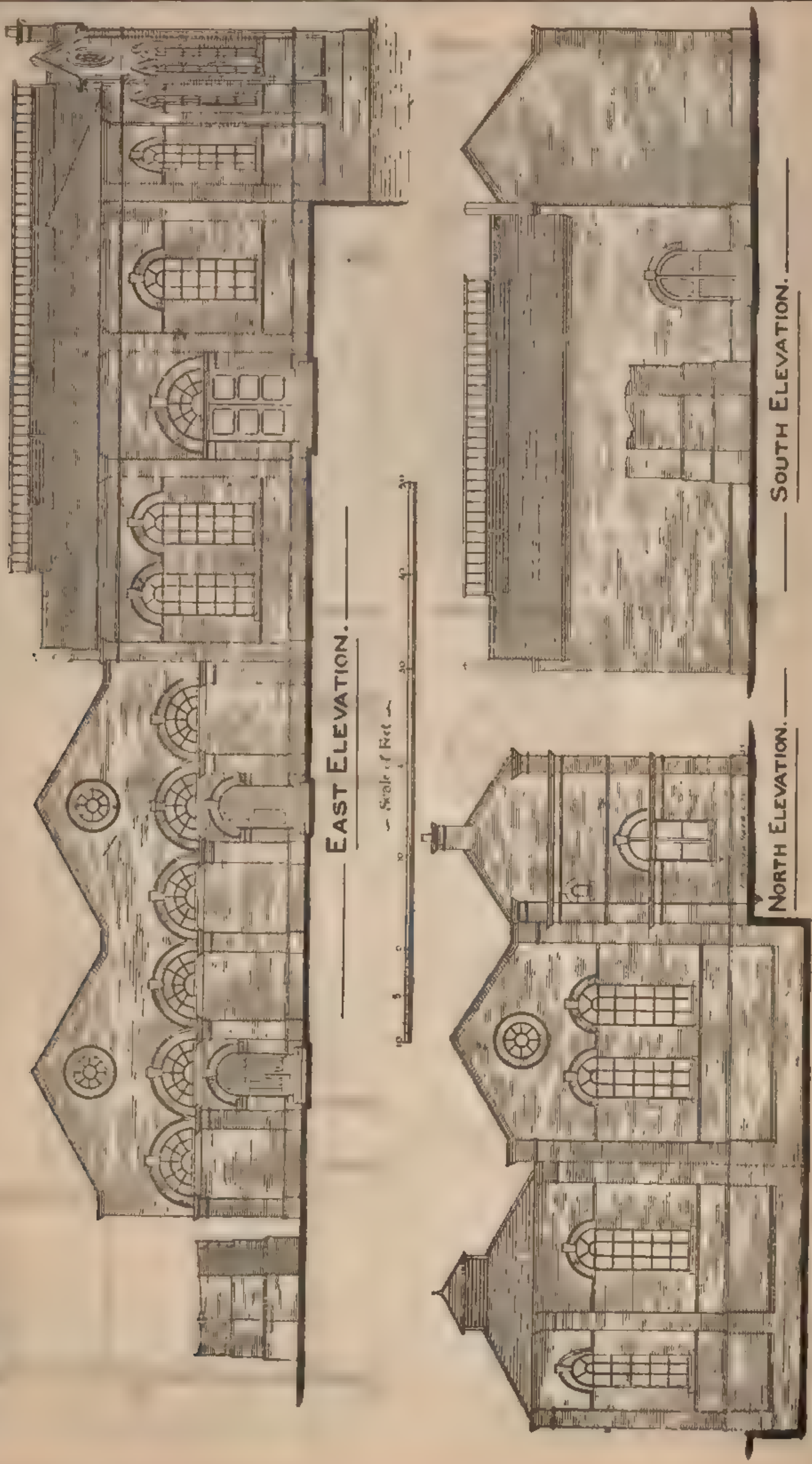
DERBY CENTRAL STATION.

It will not be necessary to enter into any lengthy history of the action of the Derby Corporation in determining to provide the electric light for the borough and to undertake the work themselves. An enlightened policy is sure to have its own reward, and within a few years, when the works reach their normal development and bring normal returns, it will be seen that the reward will be commensurate with the energy expended. Come we, then, to the time when the authorities had made up their minds and placed the designing of the station and distributing system in the hands of Messrs. Bramwell and Harris, consulting engineers of the greatest experience and highest repute.

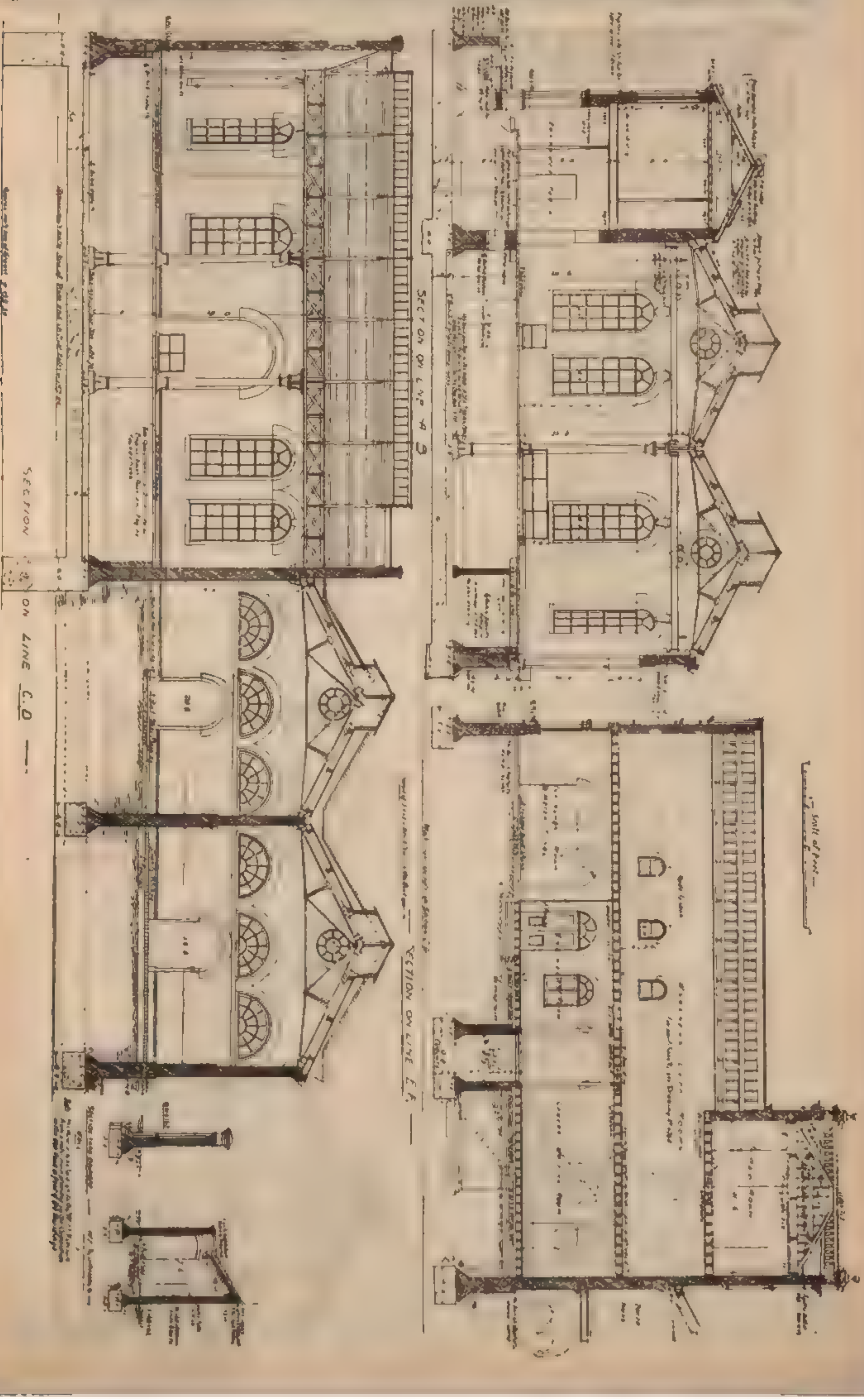
The determination of the site led to some sharp criticism, but one cannot fail to assume that engineers of so great eminence are better judges of what is best than lay critics, who are too apt to consider one prominent point only. Time alone can prove the wisdom of selection. The site actually selected possesses great historic interest. The first silk mill erected in England was built here, about 1718, by Mr. John Lombe, who procured in Italy (by, it is said, bribing two workmen, who accompanied him to England) drawings and models of the silk machinery then in use in that country, for which he took out a patent. This patent covered the operations of winding, doubling, and twisting the silk so as to render it fit for weaving. The initiator of this industry, it is said, died about four years after from poison administered by an Italian female sent over for that



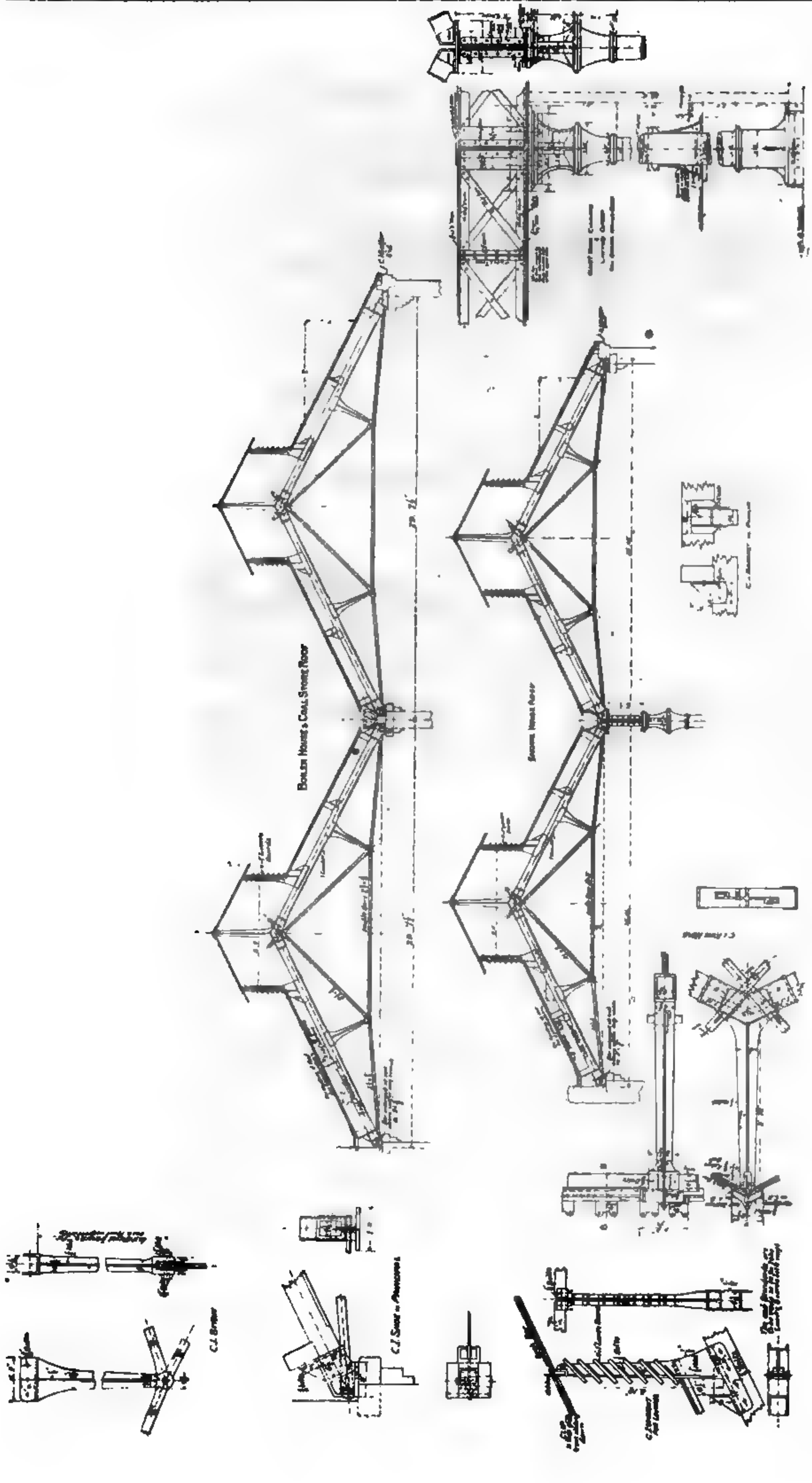
Derby Central Electric Lighting Station.—Plan.



Derby Central Electric Lighting Station.—Elevation of Buildings.

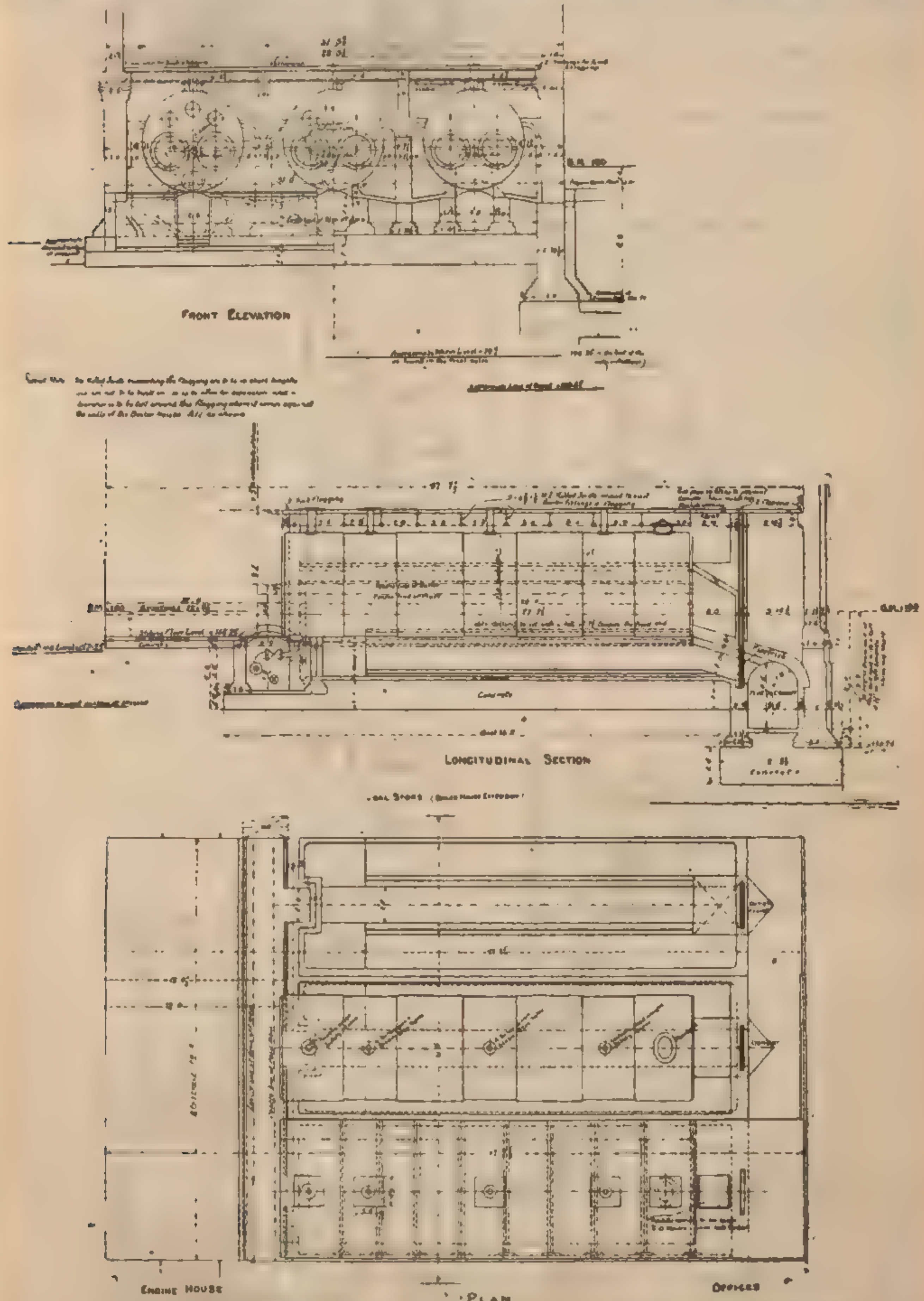


Derby Central Electric Lighting Station.—Vertical Sections of Buildings.



Derby Central Electric Lighting Station.—Roof Details.

purpose. Be that as it may, his cousin, Sir Thomas Lombe, relinquished the patent in consideration of the sum of £14,000, whereby the manufacture was thrown open and the trade rapidly increased. It seems almost a pity that Derby was not before Bradford in their electrical enterprise. To have had the first silk mill, to have had the first lightingstation, would have been achievements worthy of history. Although Derby cannot claim to be first as regards electric lighting, it comes in at a very early point in the history of such enterprises, and this shows the determination of its authorities to be among the first to patronise any phase of civilised progress as soon as it has been shown to be progress.



Derby Central Electric Lighting Station.—Boiler Section.

(Continued on page 349.)

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THE REIGN OF KING MUNICEPS.

The day is long since gone by when one might look round and notice the first movements of the tendency — now become general — towards self-government on all points of common local interest by the centres of population and industry. We are almost tired of reiterating not only the theoretical proposition that municipalities ought to take in hand the supply of gas, water, and electric light, the disposal of refuse and sewage, the provision of more rapid suburban transit, and numberless other such public duties, but also the actual fact that one local authority after another falls in line, and as the demand arises forthwith proceeds to carry out the required public service—as a rule, with perfect success.

Within the past fortnight alone, for example, so far as concerns the supply of electricity for public and private lighting from municipal central stations, we have seen the opening of such works at Manchester, Derby, and Blackpool, with some little amount of quite excusable glorification in each case. Many have preceded these, as our list of corporation authorities will show, and still more are yet to follow their example in ever-increasing number. Everyone at all well acquainted with the conditions of development in the public supply of electricity for light and power purposes must by now be fully aware of the many utilitarian advantages which lie on the side of municipal undertakings as opposed to the interests of a private company; and the same result appears, indeed, to happen whether the article to be supplied is gas, water, or electricity.

There is no need to recapitulate the reasons for this condition of things; it has grown of increasing importance each year, and to judge from results, can as yet be in no way regretted. Municipal enterprise is admittedly well able to supply centres of population with at least some requirements of healthy and prosperous living—pure water, for instance, and a good artificial light for the hours and places wherein Nature fails us.

Not only is this a matter of general agreement in regard to the equipment and ownership of gas and water works, electric light stations, etc., but the successful daily working or commercial operation of such by municipal bodies may also be considered sufficiently proved by experience. When, however, we come to the question of improvement in suburban transit methods, the installation and equipment of new tramway lines, or the purchase of those already established, with a view to increasing the facilities of locomotion from one part of a city to another, we find a widely spread difference of opinion as to the true sphere of a local authority.

There are many whose opinions cannot be disregarded, and who claim that the system of tramway lines, existing or proposed, in any centre ought rightly to be municipal property—apart, that is, from any consideration of the Tramways Act, 1870, and the powerful position in which that enactment places the local authority in regard to compulsory acquisition of the lines after a period of only twenty-one years, as compared with forty-two years in the case of electric lighting systems. But they draw the

line at mere ownership, and will not agree that municipalities should be empowered also to operate the tramways of their respective districts.

Others, again, consider that the duties involved in the working of any transit system, though perhaps of different character, are no greater than have already been undertaken by local authorities in many places; and they consider it to be unjust that shareholders in a private company should derive substantial benefit from what is to all intents and purposes a monopoly of public transit. As for that, reply the anti-municipals, in too many cases the shareholders receive next to nothing in comparison with other investments, and if the tramways are to be carried on by the local authority in each town, there would arise a grave danger of considering the passenger or employé before the ratepayer, besides which the feeling of personal responsibility is, as a rule, more acute in a management financially interested to a large extent than with a committee whose members have only to resign on account of ill-health when trouble begins. Moreover (taking the war into their enemy's camp), they say that a tramway system supported by the rates holds a most unfair position with respect to any competitive enterprise employing private capital to operate, say, a line of omnibuses.

Both sides admit the absolute propriety of local authorities taking over or owning *ab initio* the tramway systems, but the one party maintains it to be truer policy for the operation of the lines to be undertaken by a private company—of course, under suitable conditions and restrictions, and upon a terminable lease. The other party holds, in the first place, that the progress of invention and improvement in tramway matters has shown conclusively that mechanical powers are the most suitable to employ for traction purposes even along our streets. In all probability, therefore, the conversion of existing lines now operated by horse power will be largely a question of time and money; whilst new lines and extensions in many cases will doubtless be equipped with electric or cable motors.

Since local authorities are beginning to show what they can do in the way of profitably carrying on such undertakings as electricity works for the supply of light and fixed power, they ought surely, it is claimed, to be in a position satisfactorily to operate an electric tramway, the working conditions being the same for all practical purposes.

Such, in brief, is the question which is forcing its way to an early settlement, and which will therefore come very prominently before the public during the immediate future.

The general tendency in other countries has been, of course, increasingly to employ mechanical traction upon street tramways; proofs of this are seen everywhere. We print elsewhere a paper on "Earth Returns," read before the eleventh annual meeting of the New York State Street Railway Association, whose members used at first to discuss forage and fodder; in a recent issue we gave an abstract of the favourable conclusions respecting electric traction reached by the International Tramway Congress at Budapest; the Tramway Institute of our own country makes a point of meeting wherever new electric traction developments are to be found, with a view to giving its members an object lesson in the latest progress made.

Assuming, therefore, that our tramway systems are sooner or later (let it, we hope, be "sooner") to be operated by mechanical motors, the next question to be decided (and we simply state it without attempting in this place a final conclusion thereon) is the following: "Have local authorities proved themselves to be strong enough generally to undertake the confessedly difficult and often thankless task of operating tramway and street transit systems—more particularly with mechanical motors—taking into account the excellent position already attained by them in, for instance, the matter of electric supply for lighting purposes?"

Tentatively, one would feel inclined to say, that so long as local authorities can give an efficient rapid transit service with satisfaction to the public who ride, and the employes who do the hard work, and, whilst accomplishing this, are able to show a balance, however small, on the right side of the ledger, there does not seem any reason for the existence of tramway companies to operate the lines.

Probably we have thus raised a high standard, but it is one to which King Municeps must aspire, if he wishes to extend his realm. Any additions to his rule must be self-supporting, although not necessarily productive of a big revenue.

DERBY CENTRAL STATION.

(Concluded from page 347.)

As will be seen on examination of the place of the supply area, a part of the site of the old silk mill has now erected upon it the generating station. We had an opportunity of thoroughly examining the plans and seeing the work being done at the station during the course of construction, and it was gratifying to see the great care and attention which had been and was being bestowed upon every detail.

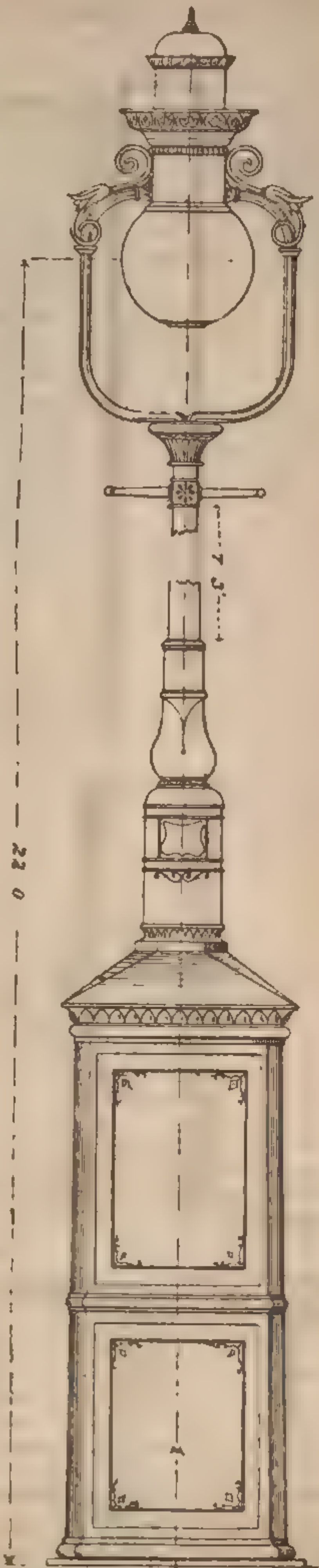
But just another word about the site. The shape is, roughly, triangular. The silk mill was built upon piles, and during the excavations for the station many of these were met with in an admirable state of preservation. The historic associations connected with the site must, however, give place to the practical, the most important of which relate to position, to suitability of foundations, and to maintenance in enabling coal to be brought to the boilers. As to position, we have said it was selected after careful examination of all the facts. Trial holes were made to ascertain its suitability for foundations, and being alongside the river, water for condensing was obtainable in quantity, and, if necessary, coal storage and water carriage was obtainable. Assuming, then, that the site was the best obtainable, the next question was the design of the buildings, and as these are fully illustrated it will be necessary to say but little about them. From first to last the engineers have had in view the saving of losses during working, and hence the minimising cost of maintenance. This in our estimation should be the aim of every designer. Initial cost is of secondary importance, cost of maintenance is of primary importance. But the electric light engineer is handicapped in other ways. He has to design for initial economy, for economy of maintenance, and at the same time allow for future and rapid extension. We must congratulate the engineers upon their careful design of this station. The plant can be duplicated with a minimum of additional expenditure.

So far as the buildings are concerned it will not be necessary to enter into lengthy description—the illustra-

tions tell more than a volume of word-painting; hence for the moment we will rest satisfied with generalities rather than with particulars. The whole of the buildings are substantially built, and special attention has been paid to the dynamo foundations, which are of concrete capped with Derbyshire sandstone. Of the electrical equipment only a part of what is even now contemplated is fixed, but the remainder is being rapidly pushed forward. There are three of Fletcher's boilers of the ordinary Lancashire type, with Galloway tubes and Vicar's automatic stoking apparatus, driven by an independent engine. Each boiler is of 200 h.p., and delivers steam at the working pressure of 120lb. These three boilers fill one bay of the boiler-shed. There is a second similar bay, and another bank of boilers can be erected as soon as required. The boilers are fitted with both injector and donkey pump. The steam-pipes are arranged so that steam can be admitted or shut off from any boiler. These pipes are carried through the boiler-room wall underneath the dynamo-room to the engines. There are two sets of exhaust-pipes—one set going to air, the other to

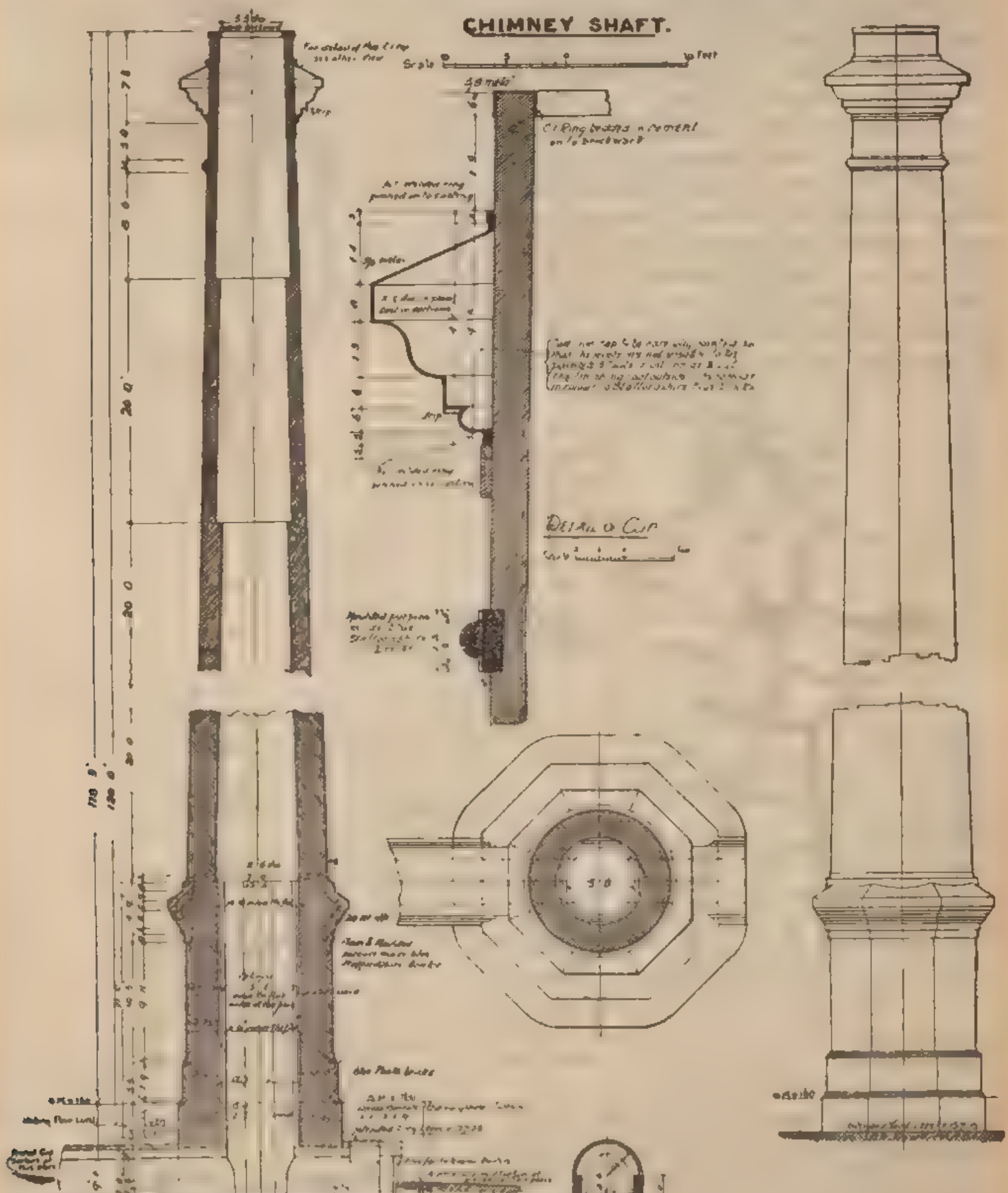
Derby Central Electric Lighting Station.—Map showing Compulsory Area of Supply.

the condenser, the circulating pump for which gets water from the adjoining river. The engines are by Messrs. Browett and Lindley, of Patricroft—vertical, compound, direct-driving, with flywheel governors. Those installed are to give 50 h.p. actual, while three others are being erected of double this power. At the present time these engines drive three alternators by Messrs. Siemens and two direct-current dynamos—the latter for the arc lighting. These alternators deliver current at 2,000 volts at 200 revolutions per minute, and have the exceedingly low periodicity of 40. The exciters are by the same makers, and run at 300 revolutions per minute. The arc lighters run at 300 revolutions, giving 10 amperes at 1,800 volts. In fact, this output is obtained at 280 revolutions. Each of the arc lighters is intended to give current to 40 lamps in series. At the present time there are two arc light circuits. The lamps are Siemens's double-carbon, to run 36 hours—that is, each pair of carbons last 18 hours; and the first pair being consumed, the second is automatically brought into circuit. The leads from the alternators are *taken to* omnibus bars, as they are intended always to run *in parallel, and from these the current* is switched to all or



Derby Central Electric Lighting Station.—Combined Lamp-post and Transformer Box.

any of the transformers on the feeder circuits. The switchboard is arranged for 12 circuits. We ought to have mentioned that the high-pressure fuses are in porcelain voltage of any feeder at the transformer can be told at any moment. The transformers themselves are housed in the columns which support the arc lamps.



Derby Central Electric Lighting Station.—Details of Chimney Shaft.

boxes, and that all the switchboard arrangements have been carefully considered, the double-pole switches being insulated with ebonite. Pilot wires are brought back to the switchboard, from which incandescent lamps are run, and by means of a switch and a Cardew voltmeter the

A few words with reference to the system of the distribution and the general features of this installation will be known. All the transformer secondaries are led to what may be termed omnibus distributing-mains, from which mains the incandescent

lamps are fed. It will be seen that when the demand is light the transformers not required to supply the demand can be switched off, and so the transformer losses at low load avoided. In fact, though there may be a little loss by this omnibus method, it will probably be far less than the loss would be by using transformers at low loads. But we hope to illustrate, and where necessary describe, the various details of the apparatus in subsequent issues.

Meanwhile, on Tuesday evening, at the invitation of the Mayor of Derby (Mr. Councillor Marsden, J.P.), a large number of the most prominent inhabitants of Derby gathered together at the central station to witness the inauguration ceremony of turning on the steam, and subsequently to dine together and felicitate each other upon the success so far achieved. The ceremony was a success, the light was a success, and the speeches were a success. The Mayor admitted that the Corporation had placed itself unreservedly in the hands of the Electric Lighting Committee, and that the committee had placed itself as unreservedly in the hands of the eminent and experienced engineers, Messrs. Bramwell and Harris. We are quite sure that this was the wisest policy to pursue, and our examination of the works when in progress and again so far completed, lead us to the conclusion that Messrs. Bramwell and Harris have designed a station worthy of the town and their own great reputation; and they have been ably seconded by the various contractors, such as Messrs. Siemens, Messrs Browett and Lindley, who have supplied the engines and dynamos and other apparatus. Nor must we forget the gentlemen who have superintended the actual work, and to whose unremitting attention the success of the work is due.

THE RETURN CIRCUIT OF ELECTRIC RAILWAYS.*

BY THOS. J. M'TIGHE.

(Concluded from page 327.)

I must not take up your time with any extensive analysis of Table III., but I cannot forbear pointing out a few striking features. Take cases Nos. 2 and 6. The former is, no doubt, used by many members of this association. No. 6 is the system track circuit of the Atlantic-avenue Railroad, in Brooklyn, N.Y. No. 2 has a total track resistance of ·0586 ohm, and costs for material about 700dol. per mile, while No. 6 has a total track resistance of but ·0130 ohm, and costs for material only 144dol. per mile. In other words, No. 6, in point of efficiency, is four and a half times a better electric circuit than No. 2, while costing just about one fifth as much

TABLE III.—Characteristics Per Mile, Double Track.

Case number.	Total R of rails.	Total R of rail bonds.	Total R of track circuit.	Fall of potential for 200 amperes	Total energy expended thus in track circuit.	Cost of such per year at 100dol. per kilowatt	Approximate cost of track circuit material
	ohm.	ohm	ohm.	volts.	watts	dol.	dol
1	·0086	·0335	·0362	7·24	1,448	144·80	700·00
2	·0086	·0671	·0586	11·72	2,344	234·40	700·00
3	·0086	·0796	·0882	17·64	3,528	352·80	90·00
4	·0086	·0398	·0484	9·68	1,936	193·60	180·00
5	·0086	·0133	·0218	4·36	872	87·20	180·00
6	·0086	·0044	·0130	2·60	520	52·00	115·00
7	·0086	·0105	·0191	3·82	764	76·40	200·00
8	·0086	·0035	·0121	2·42	484	48·40	130·00
9	·0086	·0083	·0169	3·38	676	67·60	220·00
10	·0086	·0027	·0113	2·26	452	45·20	150·00
11	·0067	·0335	·0306	6·12	1,224	122·40	1,250·00
12	·0067	·0011	·0078	1·56	312	31·20	432·00

In roads likely to have extreme heavy traffic, case No. 11 has been adopted, there being four No. 0 supplementary copper wires and the ordinary copper rail bonds or connectors, being thus merely an enlargement of No. 2, and used in connection with 90lb. rails. In case No. 12 the 90lb. rails are also used, but there are no supplementary wires, and each joint of the rails is supplied with two rail bonds of No. 0000 copper wire, each only 12in. long. Comparing results, it is evident that case No. 12 is, electrically, about four times a better circuit than No. 11, while costing only about one-third as much.

Now, let us compare case No. 12, as it stands, with case No. 11, but adding to the latter two 500,000 circular mils overhead returns connected heavily to the track circuit at frequent intervals. In case No. 11, the total track circuit resistance is ·0306 ohm; that of the two 500,000 circular mils feeders about ·0545 ohm; and the combination circuit measures about ·0196 ohm. The cost of the two feeders (insulated) per mile of double track roads would be approximately 2,800dol., to which we add the 1,250dol., cost of track circuit in case 11—making 4,050dol.

In short, though our case No. 12 gives us almost three times as efficient an electric circuit as the new case No. 11, the latter costs almost 10 times more than No. 12. And yet the West End and Brooklyn City Railroad Companies pin their faith in a circuit like case No. 11.

A glance at the sixth and seventh columns of Table III. is rather instructive. If we take a medium city system operating 20 miles of double track, the company which uses case No. 2 will pay several thousand dollars per year for the energy wasted in the return circuit, while the company using No. 6, or No. 8, or No. 10, will pay but a trifle in comparison, and save nickels by the quart. I am of the opinion that it would, to-day, well repay any company using copper supplementary wire to rebond its tracks on a basis of perennial low resistance, because on the average it would save the cost of such change in one year. And I say the same to those using iron rail bonds.

There is still another phase to this whole question of the return circuits to which I will briefly refer. I mean the electrolytic decomposition of the rails when earth is relied upon as the major part of the return circuit. That there is such decomposition must be true. The soil under our paving has for many years been plentifully soaked with ammonia from animal refuse, with ordinary salt in the winters of bygone horse-car days, and to these have been added the leakage from the underground gas-pipes. Certainly, such soil, when wet and in contact with the rails, presents all the requisite features of an active depositing bath, there being no dearth of cathodes below. Hence, so long as a considerable flow of current takes place from rails to earth, there must necessarily be a good deal of direct electrolytic decomposition of the rails. Let me take an extreme case. It would scarcely be exaggeration to assume that on Tremont-steet, Boston, or Fulton-street, Brooklyn, there is a massing of slowly-moving cars, amounting to, say, 100 for one mile of double track. Let the rails used be 70lb. girder, and for the current I should say 20 amperes per car for 15 hours per day would be a fair average; $100 \times 20 \times 15 \times 365 = 10{,}950{,}000$ ampere-hours per year. If all this went back to the generator by way of the earth, the decomposition of the rails every year would be 7,665,000 grammes, or about 17,000lb. of iron. Nearly eight tons lost from the mile of double track in one year. As the mile of 70lb. rails would only aggregate 220 tons, it would not be many years at that rate till the rails would be qualified for a pension for loss of both feet incurred in the service, and in time we might have an illustration of the proverbial "two streaks of rust and a right of way."

I have assumed an extreme case, but I have no doubt that there is a considerable amount of direct electrolysis of the rails. Nothing can be done to entirely avoid it, but it can be reduced to a minimum by overhauling the track circuit and giving it as great an electrical value as possible, and it might be retarded by dipping the rails before laying, similarly to gas and water mains. In abandoning as much as possible the rather uncertain supposed advantages of the earth return, we would to a corresponding degree rid ourselves of troubles with gas and water pipes and telephone circuits, and yet would be as safe from lightning as we are at present.

If it be admitted, then, that it is desirable to obtain from the track structure as great a conducting power as possible, the question arises, how shall it be done? This at once brings us to the subject of rail bonds, and a criticism of the various types used, with a view of arriving at the best from all points of view.

* Report read before the Street Railway Association of New York State, September 19, 1893.

There have not been many types brought out by the manufacturers. Probably the earliest was made of a piece of wire having its ends coiled around two rivets and dipped in solder. This form is still much used, but it is objectionable. By its use four contacts exist at every rail joint—*i.e.*, rail to rivet, rivet to wire, wire to rivet, and rivet to rail. To ensure its position in the rail the rivet must be upset, and this in a great number of cases either starts or completely loosens the contact between the rivet and wire. If it escapes this, the constant vibration of the rail sooner or later causes loosening of the wire on the rivet. Once looseness occurs, the bond is of little use. Again, the essential nature of such a rail bond precludes the use of any large wire in its construction. Still, many roads have used them and are still doing so. The wire generally used is No. 4 B. & S., sometimes iron and sometimes copper.

Another type which has met with much favour consists of two soft iron pins with enlarged heads, which are drilled transversely to receive the connecting wire, which is upset after passing through the heads. This form is open to the same objections as the previous one, being in three pieces, the integrity of whose contact is almost sure sooner or later to be destroyed, whether the intermediate wire is iron or copper.

Later on appeared the ingenious and, from a purely constructive aspect, very economical "channel pin." It met an enormous sale, and is to-day in extensive use. The form is familiar to you, and I need not describe it. It requires three pieces, is not capable of riveting in the rail, and its form prevents the pin and wire from completely filling the hole in the rail, and rapid corrosion of contact is inevitable. Being merely driven wedge-like into the rail hole its stay is not reliable, and by corrosion and continual vibration it becomes loose and almost valueless. There is, too, a tendency for the workman to force the wire against the sharp edge of the hole while driving the pin, thus weakening the wire very materially. It, too, like the rivet-and-wire bond, has a limitation as to the size of the connecting wire. No matter how carefully the mechanics of the job are attended to, we have a mere plug driven in a hole, and so between the rail and channel pin and the car wheels is a very good illustration of a cask, a bung, and a bung starter, with the odds against the bung.

Another type of rail bond is that composed of a piece of copper wire, with cast copper rivets electrically welded thereto on projecting stems the size of the wire. This is an attempt in the right direction, but does not work out in practice. The electric weld is apparently uncertain, the union in many cases under my inspection being so imperfect that it could be broken by hand. The small copper castings exhibit radial crystallisation, making welding difficult. Many also break in applying to the rails, and such happenings destroy confidence.

I now come to what is known as the "solid one-piece bond," which has sprung into great favour. It would be disingenuous were I not to announce right here that this rail bond is a patented invention of my own, but I hope that you will admit that I am trying to view this question from a broad and disinterested standpoint.

This solid one-piece rail bond is simplicity itself. It is merely a wire with expansion curves at its ends, on each of which a heavy shoulder is swaged from the wire itself, so that both the rivet ends thus formed and the intermediate wire are all one solid integral piece. From rivet to rivet there can be no failure of contact, except by forcible rupture or total corrosion, and there can be no failure of contact between bond and rail, because when the rivet end is properly headed up, the connection made is perfectly watertight and airtight, and it is proof against pounding and vibration. There is no solder required, no parts to shake loose, and there is no restriction in size of wire, as the bond can be made of No. 4 wire, and it can be made of No. 0000, and larger if desired.

I suppose the great majority of rail bonds used span around the fishplates, which nowadays are quite long. My belief is this is a mistake. Table III. will show what a difference there is in resistance in the track circuit as between 36in. and 12in. bonds. The 12in. bond has the advantage in the total track resistance of from 40 per cent. to 50 per cent. A 12in. solid bond, with its expansion curves, makes a distance between rivet centres of about 8in. Electrically considered, it does not matter what part of the rail end is used for bonding. The holes can be drilled through the flat "tram," or through the floor of the rail, 4in. from the end, just as readily as through the web or stem. There is no difficulty whatever, and I can imagine no type of track construction forbidding the use of short bonds. I have bonded many miles of track in this manner, and used the 12in. bonds and had no trouble. In girder rail I prefer to drill the holes through the flat tram, taper ream the holes from above, and deeply countersink; then pass the rail bond up from beneath, and head up the ends till the taper and countersink are completely filled. This method has one great advantage, in allowing every rail bond to be inspected at any time without disturbing the paving. The tracks of the Atlantic-avenue Railroad, in Brooklyn, were bonded in this way with No. 000 copper bonds, 8in. long between rivet centres, and they have given entire satisfaction.

Rail bonds should, after being applied, be either heavily coated with shellac and asphaltum, as practised by Mr. Wason in Cleveland, or have a grooved strip of wood filled with asphaltum slipped around while the compound is soft. This will prevent corrosion.

Another important element of the return circuit, in such roads as do not pass the power-house, is the main return. Whether earth circuit is used or not, there should be a heavy connection from the generator or switchboard by the shortest route to the rails. Such a course is generally adopted, but the size of the conductor is apt to be too small. I have seen several cases of serious inadequacy in this direction, so much, indeed, as to heat the main return. I had occasion once to discuss the question with a gentleman who called himself an electrical engineer, and who had engineered several railways of considerable size. The problem was to return a possible maximum of 5,000 amperes about half a mile from tracks to generator. I gave my views, which embodied rather heavy work, and also my calculations for loss of energy, etc. "Nonsense," said he, "four No. 0000 wires would be abundance, because you can lay them in the ground, and the heat will be carried off before harm can be done." It was no use arguing against that, and I utterly failed to persuade him that his four wires would required 320 volts to drive the 5,000 amperes through them—*i.e.*, a loss of over 2,100 e.h.p. Fortunately that engineer has generally had some check on him, and thus the construction of several monstrosities has been avoided.

The old rails can be advantageously used for the main return in many cases. When it comes to using a large number of heavy copper wires overhead or underground on the one hand, and on the other hand an equivalent capacity of old rails laid underground, the latter is much cheaper, and can be made entirely durable. The rails can be connected by heavy copper plates by riveting, the number of rivets being equal in carrying capacity to that of the rail and plate. The whole structure can be laid in a wooden trough filled with pitch, and will remain intact for an indefinite period. A one-rail line of this kind, composed of old 60lb. flat or centre bearing rail, is as good as a copper bar 1in. square, or six No. 0000 copper wires.

I am, therefore, led to the conclusion that the best return circuit is that which complies with the following requirement: (1) Intrinsic resistance low enough to need no help from earth; (2) utilisation to the utmost practical extent of the rails as the return conductors; (3) rail bonds of the heaviest practicable size; (4) rail bonds of the shortest possible length, consistent with due allowance for expansion and vibration; (5) rail bonds made of a single piece of wire with integral rivets; (6) rail bonds tightly riveted to the rails through holes freshly reamed immediately before bonding; (7) rail bonds so placed as to permit convenient inspection; (8) rail bonds protected against corrosion; (9) a very liberal use of heavy cross bonds from rail to rail direct, and, in double track, extra heavy cross bonds connecting the two inside rails; (10) an underground main or trunk return from the power-house to track, and there connected to each line of rails, and low enough in resistance to carry the maximum current with but a nominal drop in potential.

Not one of these requirements is an extravagance, but, on the contrary, their proper application to almost any electric railway in the country would be of immediate and lasting benefit. In new constructions they would be a positive economy in first cost. There is not one of them which cannot be adopted in practice, and it seems obvious that their complete embodiment in any existing road would be immediately noticeable in the power-house, and eventually in the dividend.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE II.

THE STORAGE OF ENERGY AND THE DEVELOPMENT OF ENERGY BY WATER POWER.

In most applications of the energy derived from fuel the fluctuation in the demand for power involves waste. But it is in steam central stations which have to work during 24 hours, during which the demand for power varies very irregularly, that the waste due to irregular working has been most serious. Of all central stations, electrical central stations are those which have to meet the greatest fluctuation of demand for energy, and the waste so occasioned has compelled electrical engineers, more than any others, to seek for means of storing energy.

To completely meet a fluctuating demand by generators of energy worked at a uniform rate, there must be storage of energy satisfying two conditions. Twenty four hours may be taken as the natural period of the fluctuation of demand for energy. In each 24 hours there will be two periods—one in which the demand falls below the average demand, and one in which the demand exceeds the average demand. The excess of energy supplied during one period will on the average be equal to the deficiency in the other period. If the generators are worked at a uniform rate, then all the energy supplied in excess of the mean demand in one period must be taken from storage, and must have been put into store during the period in which the demand fell below the mean demand. But this is not the only condition to be satisfied. With some kinds of storage, the rate at which energy can be taken out of store is unlimited. In other cases it is limited, and then the storage must be so arranged that the rate at which energy can be taken out of store is equal to the difference between the maximum rate at which energy is required and the mean rate.

Gasholder Storage.—The distribution of gas is not strictly a distribution of energy, but only of the means of conveniently obtaining it. But a gas lighting distribution is analogous to a distribution of energy, and the demand varies nearly as much as in an electrical distribution. The gas engineer is happy in having a convenient and cheap means of storage. Usually about 24 hours' supply of gas is stored in the gasholders at a gas generating station. Hence the gasmaking plant can be worked at an almost uniform rate day and night. Taking 25 cubic feet of gas as capable of yielding one effective horse power hour of energy, it appears that gasholders cost about 5s. 6d per effective horse power stored. Mr. Trewby puts the cost of gasholders at a London station at £10,000 per million cubic feet of gas supplied per day. In that case such a station works virtually at 1,666 effective horse-power, and the cost of the gasholders is £6 per effective horse-power, reckoned on the average rate of supply throughout the year. Here, allowing 10 per cent for interest and depreciation, the storage adds about 12s. per effective horse power to the annual cost.

Accumulator or Battery Storage.—The electrical engineer would be glad to have a means of storage equivalent to a gasholder. For a time it was thought that such an equivalent had been found in the storage battery. The use of such batteries is limited to continuous current systems, and they have besides the practical defects (1) that the maximum rate of discharge is limited, and (2) that about one fifth of the energy stored is wasted. Nevertheless, they would have been an extremely important factor in electric central station working but for their excessive cost. With a 24 hour load line, such as that of most electric lighting stations, the amount of storage required to enable the generators to work at a uniform rate may be defined thus: the battery must be capable of supplying energy at a rate equal to three times the mean rate of supply for the 24 hours. Also, it must be capable of storing during one part of the 24 hours, and restoring in the other about half the whole supply for the 24 hours.

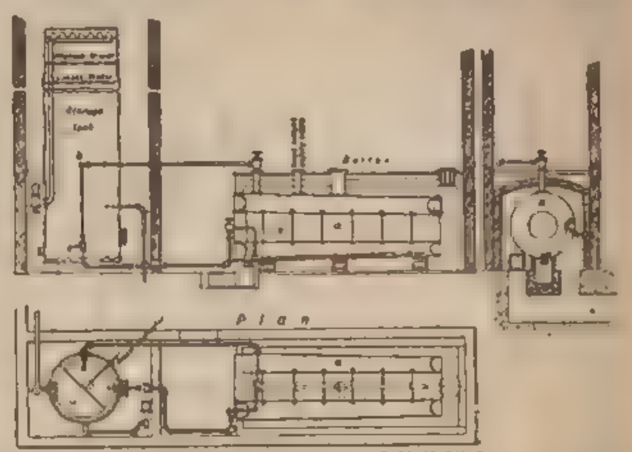
The cost of storage batteries prohibits their employment on this scale in large stations. Employed in a limited way, they serve some useful ends. In some stations they supply the energy required for 10 to 13 hours out of the 24, during which time the engines are stopped. They diminish the fluctuation of load of the engines during the time in which they are running, storing energy not required in the external circuit. But they do not obviate the necessity for having a varying number of engines at work. Prof. Kennedy puts the case well when he says that they enable the station to be shut down for some hours and act as flywheels, smoothing the irregularities of supply.

* *Howard* Lectures delivered before the Society of Arts.

Cost of Accumulator Batteries. From data given me by Prof. Ayrton, it appears that eight Epstein cells, tested in the laboratory, would work at 1 h.p., and store a charge for 2½ horse power hours. The cells cost, without allowance for buildings, insulation, or switching arrangements, or for waste of energy, £20. That is, the bare cost of the cells amounts to £20 per horse-power reckoned on the maximum rate of working, or to £8 per horse power hour stored. Suppose a station working at an average of 500 h.p. The maximum demand in the 24 hours would be 2,000 h.p., of which 1,500 would have to be supplied from the battery. The cost of the battery to supply energy at the necessary rate would be £30,000. During 24 hours the quantity of energy supplied would be 12,000 horse-power hours, half of which must be stored. Batteries of sufficient capacity would cost £48,000. Here the latter condition determines the cost. Taking interest at 5 per cent., and maintenance and depreciation at 12½ per cent., the annual cost of the battery would be £8,400, or nearly £17 per horse power of average rate of working of the station. This is the bare cost of the cells without buildings, adjuncts, or reserves.

In a project for lighting Frankfort-on-Main, Mr. Oskar von Miller and Mr. Lindley provided large secondary battery stations. The batteries had a capacity of 11,700 ampere-hours, and were capable of supplying a current of 3,500 amperes at 100 volts. The batteries, with wood platforms, insulation, etc., were taken to cost £25,100, and the buildings for them £11,600. This is equivalent to a capital cost of £23 per horse-power hour of storage capacity, or £78 per horse power power reckoned on the maximum rate working.

Thermal Storage.—Secondary batteries, being too costly as a means of storage, except on a very limited scale, the question arises, is any other means of storage available in conjunction with steam-engines? Some means of hydraulic storage will be considered later; such means are rarely applicable for the storage of steam power. Lately, Mr. Druitt Halpin has proposed a system of thermal storage which appears, in many respects, to meet the conditions required. Energy is first obtained in steam-power stations in the form of heat. Can the heat be directly



THERMAL STORAGE BOILERS AND STORAGE TANKS

FIG. 10.

stored? Heat is a very unprisonable form of energy, escaping through all bodies and in all directions. But, in New York, steam is transmitted through miles of pipes, and, by reasonable jacketing, the loss of heat is reduced to a moderate percentage of that carried. In a properly constructed storehouse for heat with reservoirs, closely packed and presenting little external surface, the radiation loss need not be large. For storage, heat must be imparted to a material body of large heat capacity. It is easily given to water in boilers of ordinary construction. A body of water, highly heated, in a well insulated chamber, will store a large quantity of heat. To permit the water to be heated it must be kept under the pressure corresponding to its temperature. The task of storing a mass of heated water presents no mechanical or physical difficulty. It is a condition of any system of heat storage for central stations that the energy stored should be recoverable whenever and at any rate of supply required. Heated water fulfils the condition. If the pressure is reduced steam is generated instantly and in controllable amount. The steam generated can be used in the engines to generate mechanical energy as it is wanted.

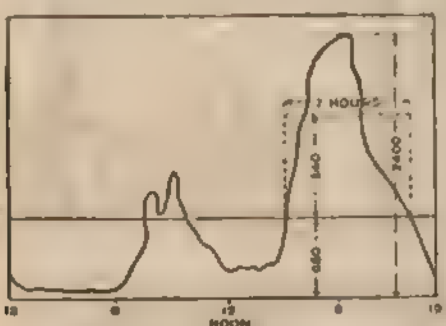
Mr. Halpin's plan is, therefore, to communicate heat in boilers to a body of water. The heated water is stored in reservoirs under pressure. From the reservoirs steam is taken through a pressure-reducing valve exactly when and in what quantity it is required. Mr. Halpin proposes that the heat reservoirs should be under a pressure of 265lb. per square inch (absolute) when fully charged, the corresponding temperature being 406deg. F. He proposes that the steam engines should be worked at 130lb. per square inch, corresponding to 347deg. F. The total heat stored when the reservoirs are fully charged is the difference of the total heat of the water at 406deg. and 347deg. F., or the heat due to a range of temperature of 59deg. Every pound of water falling in temperature through that range will yield 61 thermal units of heat. But the total heat required to generate a pound of steam at 130lb. per square inch from water at 347deg. is 868·8 thermal units. Consequently 14¼lb. of water falling in temperature from 407deg. to 347deg. will yield a pound of steam.

To allow for radiation, loss, and imperfect working, this may be taken at 16lb. of water per pound of steam. A simple cylindrical reservoir, 8ft. in diameter and 30ft. long, will contain 84 000lb of heated water. Such a reservoir would be capable of generating, under the conditions supposed, 5,250lb of steam at 130lb per square inch. The steam consumption may be taken to be, per effective horse power, 18lb. per hour in condensing and 25lb. in non condensing engines. Hence one such reservoir would store 286 effective horse power hours if the steam is used in condensing engines, or 210 effective horse power hours if the steam is used in non-condensing engines. If the reservoir were fully charged and discharged daily it would yield 104,400 and 76,660 effective horse-power hours of stored energy yearly in the two cases. A reservoir, 30ft. by 8ft., would cost, erected, with ample allowance for buildings and appendages, £470. As it is not exposed to fire, its deterioration would not be considerable, and 10 per cent. would be sufficient to cover interest, maintenance, and depreciation. Hence, the first cost of such reservoirs, reckoned on their storage capacity, and the annual cost per horse power added to stored energy by the cost of storage, would be as follows :

—	Cost of reservoirs per effective horse-power hour of storage capacity.	Annual cost of storage per horse power supplied from reservoirs.
Condensing plant . ..	£1·64	£3·94
Non-condensing plant	2·24	5·37

The cost in the last column is the cost due to 8,760 effective horse-power hours annually.

Mr Halpin's plans appear to be practicable and to promise considerable economy in stations where the load fluctuates greatly, but they are untried, and it would not be fair to omit to point out that there are details of working involving difficulties which must be met. The cost of the mean annual horse power supplied is not inconsiderable, but it is not prohibitive. The waste in irregularly working stations is so large that *primâ facie* it may be assumed that there is economy in storage on Mr. Halpin's system



TYPICAL DIAGRAM 2600 H P STATION

Fig. 11.

But it must be remembered that this system attacks the boiler waste only and leaves the engine waste due to varying load untouched To a certain extent the latter losses can be mitigated by the sub-division of the engines.

Arrangement of Thermal Storage Reservoirs on Mr. Halpin's Plan. – It is possible that the best way of working thermal storage tanks is not yet known, but one arrangement proposed is shown in Fig. 10. The steam-boiler, *a*, is completely filled with water, the storage tank, *b*, nearly so. The two are in free communication by a system of circulating pipes. There is an ordinary feed-pump supplying water direct to the boiler or the storage tank. But instead of keeping the water in the boiler at a nearly constant level, the level in the storage tank is kept nearly constant. In addition, there is a circulating pump maintaining a rapid current of water from the boiler to the storage tank, and, consequently, back from the storage tank to the boiler. Water heated in the boiler is constantly being sent to the storage tank, and water cooled by disengagement of steam is returning to the boiler. The steam spaces of the tanks are all in communication. The pressure there will be the steam pressure due to the hottest tank. The steam required is taken off through a reducing valve. It will then be generally dry, or slightly superheated, in consequence of wiredrawing, which is advantageous for the efficiency of the engines. In a station with thermal storage tanks, the boilers will be of a size sufficient to supply the mean demand for steam on the day during the year when the demand is greatest. The boilers will be worked continuously at a nearly uniform rate, like a bank of gas-retorts. The heat not required in hours of small demand will be stored in the tanks. The excess of heat required to generate steam in hours of great demand will be taken from the store in the tanks.

Example of a Station Worked in the Ordinary Way and with Thermal Storage Tanks. The example in Fig. 11 has been worked out by Mr. Halpin. He takes a case of an electric lighting station where with the normal mid winter load the daily output is 15,600 effective horse power hours, or the mean rate of working 650 effective horse power. In ordinary conditions, without storage, engines and boilers capable of working to 2,400 h.p. would be required during the short period of maximum demand. With thermal storage tanks the boilers would be of 650 h.p. only, but, on the other hand, thermal storage tanks must be provided capable of generating all the steam required in excess of 658 h.p. when the demand exceeds that amount. An examination of the load curve shows that 5,900 effective horse-power hours would meet the whole demand in excess of the mean demand. Taking 16lb. of heated water to supply 1lb. of steam, 360lb. of water stored would generate steam enough for an effective horse power hour. Then the storage tanks must contain 900 tons of water; 24 tanks, 30ft. by 8ft., would have sufficient capacity. Without storage tanks: Eight boilers, each with 2,000 square feet of heating surface and two boilers in reserve. Cost of 10 boilers, with erection, pipes, and pumps, £10,300. With storage tanks: Two similar boilers and one in reserve, and 24 thermal storage tanks. Cost of three boilers and 24 tanks, with erection, pipes, pumps, etc., £15,000.

The cost of the plant is greater with the storage tanks by £4,700. Taking interest and depreciation at 10 per cent., this would correspond to an annual charge of £470, or about the value of 470 tons of coal at London price. But if the saving of waste by having boilers regularly, instead of irregularly, worked were only $\frac{1}{4}$lb. per effective horse-power hour, the annual saving of coal would be 1,270 tons.

Cases still more favourable for the application of the thermal storage system are those where heat is now absolutely thrown away The destructor for ash bin refuse, which has already been described, must be worked continuously day and night. This makes it difficult to utilise the heat. But with thermal storage tanks the heat might be captured and stored for use at hours when mechanical work had to be done. In such a case the advantage of thermal storage would seem to be very great. One other similar case has been thought of by Mr. Halpin. In the production of lighting gas, about 312lb. of coke are burned per ton of coal carbonised The heat in these products of combustion is now entirely thrown away. If they were taken through the flues of a boiler they might be reduced to 600deg. before escaping They would furnish about 759lb. of steam per ton of coal carbonised, or about 25 effective horse power hours.

Water Power.

Where there exists a natural waterfall, with a considerable and regular flow, and where local conditions are favourable for the construction of the necessary works, water power is generally cheaper than steam power The water costs little or nothing; the cost of maintenance of hydraulic machinery and the cost of superintendence are small; the power is regular, controllable, and convenient. In such cases, the annual cost of the power consists almost entirely of interest charges on the capital expended in works and machinery. With some exceptions, water power is at present utilised in the neighbourhood of a natural waterfall. The usual means of transferring the power of the fall adopted, till a recent period, has been the conveyance of the water itself in canals and pipes. In some cases water has been thus conveyed for hydraulic mining and manufacturing purposes very considerable distances. But a more convenient and cheaper means of transmission would greatly increase the availability of water power, and the relative importance of steam power and water power would, in some countries, be very considerably changed

It appears from a report by Mr. Weissenbach that in 1876 70,000 h.p. derived from waterfalls were applied in manufacturing in Switzerland. Probably the amount now employed is at least 80,000 h.p. It is estimated that the total available water power in Switzerland amounts to 582,000 h p. Putting the annual value of a horse-power at £6, this represents an annual value of £3,500,000. Used to replace steam power it would save annually 1,250,000 tons of coal. It is stated that at the present time Switzerland pays £800,000 annually to other countries for coal.* Nearly the whole of this expenditure could be saved if its natural wealth of water power was utilised. The recognition of the importance of this supply of power is exciting great interest in Switzerland, and there is hardly an important factory which is not either using water power or making preparations or surveys with a view of doing so.

The utilisation of water power often involves the construction of large permanent works, such as river dams, reservoirs, and canals. Mr. Emery estimates that at Lawrence, in the United States, £200,000 was spent on works, independent of the hydraulic machinery, and at Lowell a still larger sum.† Such extensive works can be best executed by an association in the interest of many consumers. Thus is created a water power company, who establish what is virtually a central water power station and a distribution of power at a rental to consumers. In the American cases, as already stated, the water itself is distributed in canals to consumers at a level permitting the creation of a waterfall at the mill or factory. But in certain other cases a further step was taken. the water power company utilised a natural fall and erected the necessary turbines, and then transmitted the power in the form of mechanical energy to consumers. Installations of such a kind, now of a quite respectable antiquity, were erected at Schaffhausen, Freiberg, Zurich, and Bellegarde. In these cases the means of transmitting power adopted, admirable as it was, had limitations and the extension of the works was restricted. Now that there are new means of transmission, the Schaffhausen and Zurich power generating stations are being increased, and a new and remarkable installation has been erected at Geneva.

(To be continued.)

* Reifer. Berechnung der Turbinen.

† "Cost of Steam Power." C. E. Emery, *Trans.*, Am. Soc. of Electrical Engineers, vol. x., p. 123.

BUSINESS NOTES.

Dover.—The establishment of Messrs. Chitty is to be provided with electric light.

Wirral.—A telephone is to be provided by the Board of Guardians for the workhouse.

Great Northern Telegraph Company.—The receipts during September amounted to £23,600.

Copper.—The price of copper in Newcastle varies from £46. 10s. to £46. 17s. 6d. for tough copper.

Bath.—The Watch Committee have complained of the failure of the electric light on certain evenings.

Western and Brazilian Telegraph Company.—The receipts for the week ended October 6 were £3,435.

St. Olave's (London).—The new offices of the Board of Works in Vine street are to be lighted by electricity.

Paisley.—The question of lighting Hawkhead Asylum is under the consideration of the District Lunacy Board.

Greenock.—Messrs. J. and R. Houston, engineers, of Greenock, have just fitted up their works with the electric light.

Belfast.—A site for the station has been chosen, and the specifications and plans are being prepared by Prof. Kennedy.

Grimsby.—A sub committee of the Town Council is to be appointed for the purpose of promoting a provisional order.

Chesterfield.—The Town Council has given the National Telephone Company notice to remove all posts from the streets.

Hammersmith.—The Vestry is negotiating for the supply of electric light to the shopkeepers and public buildings in the parish.

Blackpool.—The question of the electrical *fête*, which commences to-day, was discussed at a meeting of the Town Council last week.

Bedford.—The Town Council have resolved to transfer the powers contained in their provisional order to the Bedford Electric Light Company, Limited.

New Business.—Mr. N. F. Nalder has started business as a maker and repairer of all kinds of electrical instruments at 8 and 10, Charing Cross-road, W.C.

Glasgow.—The Town Council have agreed to increase the salary of Mr. William Arnot, the electrical engineer of the Corporation, from £250 to £350 per annum.

Richmond (Surrey).—Allotment letters have been issued by the Richmond (Surrey) Electric Light and Power Company, Limited, of 4, Sun-court, Cornhill, E.C.

Liverpool Overhead Railway.—The secretary, in reference to the issue of 2,500 preference shares, states that letters of allotment and regret have been posted.

Heywood.—The Local Government Board have sanctioned the borrowing by the Heywood authorities of £3,500 for machinery and electric lighting at the sewage works.

Submarine Cables Trust.—On and after the 16th inst., the sum of £1. 15s., on account of the coupon due on the 15th inst., will be paid by Messrs. Glyn, Mills, and Co.

Whitby.—The question of obtaining an electric fire alarm has been referred to the Fire Committee of the Local Board, who will meet and examine the tenders which have been received.

Stockport.—Mr. W. Lees said at a meeting of the Town Council last week that in the future the town would have to undertake considerable expenditure in the matter of electric lighting.

Burnley.—At a meeting of the Town Council last week Councillor Williams asked for some explanation as to the transformer to be purchased at a cost of £200 for the electric lighting station.

Aberdeen.—The Gas Committee of the Town Council have accepted the tender of Messrs. Crompton and Co., Limited, to supply copper connections for the electric mains at 1s. 1d. and 8d. per pound.

Admiralty List.—Messrs. Paterson and Cooper have been placed on the Admiralty list for dynamos. The firm have for several years been on the list for general fittings, and have recently completed a large order.

Dover.—The Council have been recommended to adopt the memorandum and articles of association of the Dover Electric Supply Company, Limited. A site has been chosen for the station on the Tennis Club grounds.

Bournemouth.—The Town Council have resolved to apply to the Local Government Board for power to borrow £200 to provide a means of communication between members of the volunteer fire brigade, as agreed upon previously by the Council.

Edison Swan Lamps.—The Edison and Swan United Electric Light Company, Limited, announce that a reduction has also been made in the price of their extra special lamps of from 32 c.p. to 100 c.p. Particulars are given in our advertisement columns.

South Shields.—The Town Council have received 49 applications for the post of electrical engineer to the Corporation, and the following selected from the number: John Christie, Glasgow; S. V. Gilham, Newcastle; Joseph A. Jeckell, Norwich; and W. Howard Tasker, London. Mr. Jeckell has been appointed by 15 votes to 10.

St. Neots.—An application of Messrs. Jordan and Addington for permission to erect telephone wires across certain streets to Eynesbury and the railway station has been referred to a committee of the St. Neots Local Board to report to the next monthly meeting.

Direct United States Cable Company.—The Directors have resolved upon the payment of an interim dividend of 3s. 6d. per share, free of income tax, being at the rate of 3½ per cent. per annum for the quarter ending September 30, payable on and after the 24th inst.

City and South London Railway Company.—The receipts for the week ending October 8 were £813, against £859 for the same period last year, or a decrease of £46. The total receipts for the second half year of 1893 show an increase of £409 over those for the corresponding period of 1892.

Islington.—A deputation of the Islington Labour League have suggested to the Vestry that if the installation of the electric light in the parish should be decided on, the contracts should contain a clause stipulating that workmen living in the district should be given preference of employment.

St. Pancras.—The Vestry invite tenders by the 16th inst. for the building of a chimney shaft at East St. Pancras Station, King's-road, N.W. The Vestry has accepted the tender of Messrs. E. Houghton and Son, of Stroud Green, at £1,876. 4s., for the extension of the Regent's Park central station.

Rotherhithe.—Mr. Thomas, the surveyor of pavements, reported at a meeting of the Vestry last week that the London Electric Lighting Company had taken up several footpaths in the parish, but had failed to reinstate them properly. The clerk was instructed to write to the company on the matter.

Lambeth.—Mr. Honey reported at a meeting of the churchwardens and overseers that the City and South London Railway had recently very much improved as a property. Its traffic was increasing day by day, and he thought the time had arrived when it should be revalued for the purpose of assessment.

Telephony.—A telephone wire has just been completed between Inverness and Foyers, with connections to Whitebridge and Gorthlick. The Post Office authorities have made arrangements for the receipt and delivery of telegrams at their offices in the district. Messages will be telephoned to and from Inverness.

Chiswick.—Mr. Waters enquired at a meeting of the Local Board last week, if there was any further movement with regard to the provision of the electric light in the district. Mr. Ramsden stated that he had arranged to make an appointment with Mr. Grant as soon as that gentleman came back from his holidays.

Portsmouth.—The Electric Lighting Committee of the Town Council have submitted a certificate from Messrs. Waller and Manville for payment to the contractor for the erection of the electric lighting station in Gunwharf-road of the sum of £600, and recommended that the amount be paid. This recommendation has been adopted.

Leamington.—The Telephone Sub Committee of the Town Council have been in communication with the National Telephone Company, and they have recommended that the cost should be ascertained of the Council's putting down its own telephone plant for communication between its various public offices. This recommendation has been approved.

Appointment Open.—A thoroughly practical man is required as foreman of gas and electrical fitters. Must be capable of estimating and superintending the carrying out of both electric and gas work. Age not to exceed 35. Wages £3 per week. Applications are to be sent to the Manager, Gas Fittings Company, Limited, 126, Duke street, Liverpool.

Battersea Polytechnic Institute.—The following appointments are now open: Lecturer in technical electricity, salary £250; assistant lecturer in mechanical engineering, salary £150; engineer to have charge of electric lighting and heating and assist in workshop. Full particulars on application to the secretary of the Battersea Polytechnic Institute, S.W.

Tenders Wanted for Cardiff.—Tenders are required by not later than the 16th inst. by the Cardiff Corporation for the supply of electric light cables, and for drawing in certain portions and making all necessary joints. Particulars may be obtained on application to the borough engineer at Cardiff, or of Mr. W. H. Massey, 25, Queen Anne's-gate, Westminster.

West Derby.—On the occasion of the starting of the new refuse destructor at the works of the Local Board on Tuesday, Mr. F. C. Everett (the surveyor) said that while useful for completely destroying the rubbish of the district, the heat from the destructor might be utilised for the heating of baths and washhouses, or for generating power to light the district by electricity.

Llandrindod Wells.—A discussion has taken place at a meeting of the Local Board on the subject of introducing the electric light to the district, and the Clerk gave an account of the system adopted at Dolgelley, North Wales, where he had lately seen it in operation. It was generally considered very desirable that steps should be taken to introduce the system, if possible.

Dundee.—The demand for installations of the electric light has been steadily increasing in Dundee since the works were completed. Of the 6,000 lamps which the present plant can supply, as many as 4,000 have been applied for and are now being supplied, and it is expected that the remaining 2,000 will also be in use very soon. The Gas Commission have considered the question of lighting the old steeple tower by electricity. The Works Committee is to report on the matter.

Omnibus and Tramcar Electric Lighting Company, Limited. This Company has been registered with a capital of £60,000 in £5 shares to acquire the business of the Universal Electric Lighting Company, and to carry on and extend it. Signatories to the memorandum of association are: A. W. Stormont, A. L. B. Kerr, W. J. Griffiths, J. F. Rogers, J. A. Lloyd, H. H. Clayson, R. Wolfenden.

Hanley.—The members of the committee who have been entrusted with the work of preparing for lighting Hanley by electricity are manifesting great activity. The footpaths and crossings in many of the central streets have been taken up, and the cables have been laid down. The positions of the transformer chambers have been agreed upon, and the localities have been selected for the arc lamps to be used.

Tenders for Aberdeen.—Tenders are invited by the 25th inst. for supplying boiler, engine, dynamo, and other electrical plant for the Northern Co-operative Company's central premises. Specifications may be obtained from the secretary, 54, Loch-street, Aberdeen. A charge of £1 will be made for copy of specification, and will be returned on a *bonâ fide* tender being received. Tenders to be marked "Tender for Electrical Plant."

Keighley.—The annual report of the gas engineer to the Town Council, presented at a meeting of the latter, referred to the question of electric lighting at considerable length. It was mentioned that arrangements were being made to inspect the installations at Leeds, Bradford, Morecambe, and in other towns. It was estimated that the cost of a plant to supply the principal streets in Keighley would be from £15,000 to £20,000.

Halifax.—At the Drill Hall on Monday a trades and industrial exhibition was opened. The hall has been tastefully decorated by Mr. E. Booth, of Southgate, and the electric light is supplied by the Halifax Mutual Electric Company. Three arc lights, each of 2,000 c.p., are suspended from the roof, and a lamp of like power hangs over the Prescott-street entrance, while outside upon the roof there is a revolving search light of 10,000 c.p.

Leeds.—In anticipation of the tramways of the city being transferred from the Tramways Company to the Corporation, the Highways Committee are now considering what improvements shall be made in the system. The demonstration of the utility of electricity as a motive given on the Roundhay Park Tramway has made a favourable impression in the community. The Highways Committee have arranged to visit Walsall and Darlaston for the purpose of inspecting the system and judging whether it would be suitable for Leeds.

Coventry.—One of the principal additions to business premises is the fine and original block of buildings in High-street erected by the Coventry Gas Fittings Company. The right hand window as one enters the building will be used for exhibiting three Otto gas engines by Messrs. Crossley, of Openshaw, Manchester. One will be used for driving a dynamo for lighting the premises by electricity, a second will work a hoist erected at the rear to convey goods to either floor, and the third will simply be for exhibition, though also in motion.

British Volta Glow Lamp.—The prospectus is being circulated of the British Volta Electric Glow Lamp Company, Limited, whose capital is £2,000, in 2,000 shares of £1 each, of which 1,600 are now offered for public subscription. The balance of 400 shares is issued to the vendors, fully paid up, in payment for patents, etc. This company is formed to acquire, work, and develop a provisional patent for improvements in electric incandescent lamps, and other processes in connection with their manufacture, to establish lamp factory, and to supply incandescent lamps.

Tenders for Manchester.—Tenders are invited for supplying and fixing electrical plant, vertical engine, dynamos, accumulators, and all necessary connections and appliances required to light the sewage works at Davyhulme, for the Rivers Committee. Copy of specification and all particulars may be obtained on application to Mr. John Allison, city surveyor, Town Hall, Manchester, on deposit of £1. 1s., which will be returned on receipt of a *bonâ fide* tender. Tenders to be addressed to the chairman of the Rivers Committee, endorsed "Tender for Electrical Plant, Davyhulme," and delivered at above office by 17th inst.

Redruth.—The electric light is gradually increasing in favour at Redruth. Messrs. Beringer and Schwerer, jewellers, have adopted it, and the illumination is greatly admired. In the basement a small Tangye gas engine drives a dynamo designed by Mr. E. W. Tangye, and the current generated supplies 11 incandescent lamps, which give a total of 200 c.p. The engine consumes about 40 cubic feet per hour, which it is estimated will compare very favourably with gas lighting, besides the further advantage of the goods not being injuriously affected by the light. The plant at Messrs. Beringer's was installed by Mr. E. W. Tangye.

Newcastle.—The Town Moor Management Committee of the Newcastle Corporation met the other day. The question of the fountain and electric light, which the Council at its last meeting decided to set up in the Leazes Park, was discussed, and the city engineer was instructed to get tenders for the work immediately for the fountain and lamp, in order that the light might be ready for the skating in winter. At a meeting of the Town Council, Mr. A. Hepburn moved the appointment of a committee to consider the question of the Corporation providing the electric light in Newcastle. Mr. J. Barker Ellis seconded the motion, which was carried.

Sunderland.—At a special meeting of the Highways Committee of the Corporation, the borough surveyor reported the receipt of further specifications from Prof. Kennedy, enabling him, after conferring with the professor a little more as to some details, to advertise for tenders for laying the outdoor plant. There will be three contracts to let—one for cutting the roads and making culverts so as to carry the wires underground, one for metal pipes and castings, and one for stoneware pipes and insulators. It was agreed that the borough surveyor should confer with Prof. Kennedy on the points he wanted explaining, and that he then should be left to advertise for the tenders.

Brazilian Submarine Telegraph Company.—The report of this Company for the half year ended June 30, shows that the revenue amounted to £106,859, and the expenses to £40,580. After providing for debenture interest, sinking funds, and income tax, there remains a balance added to the amount brought forward of £56,043. A quarterly interim dividend has been paid, and £7,000 transferred to reserve, increasing that fund to £638,675. The Directors recommend a final dividend of 3s. per share, making 6 per cent. for the year, and a bonus of 1s. per share, both tax free, leaving a balance of £3,533 to be carried forward. The dividend and bonus will be payable on the 19th inst.

Monmouth.—With reference to the schemes sent in for competition for the drainage of the town, the Mayor stated at a meeting of the Council last week that the plans had been sent to Mr. Lailey, civil engineer, and he would select the best two schemes towards the end of the week. He had received a letter from the Brush Electrical Engineering Company, stating that they would prepare all the necessary plans required by the Local Government Board to be presented at their meeting and would also attend the meeting, when it took place, free of charge. As soon they got the plans they would no doubt appoint an enquiry here. The question was rather an important one as to whether it was advisable to employ a barrister to give them his help at the enquiry. On the proposition of Alderman Hyam, seconded by Councillor Breakwell, it was decided that a barrister should be retained. The town clerk was instructed to take the necessary steps to obtain a provisional order for electric lighting.

Edinburgh.—The Lord Provost proposed at a meeting of the Town Council on Tuesday that Mr. Mackenzie should make an interim report in regard to what he had done regarding the purchase of a site for an electric light station. He might say that they hoped to be able to supply the electric light about the end of next year, and people who wished the light should be beginning to get their houses wired. Mr. Auldjo Jamieson objected to an interim report being made on this subject, when information was denied on another and more pressing question at an earlier part of the meeting. Mr. Mackenzie then made his interim report, the effect of which was that he had been able to purchase a site for an electric station at Dewar place, at a cost of £7,322 and that the site had the approval of Prof. Kennedy, their advising engineer. The purchase was approved of, and the chamberlain authorised to pay the money. On the proposal of Mr. C. S. Brown, it was agreed that Prof. Kennedy's report should now be circulated.

Contract Dispute.—At the Cardiff County Court last week, before Judge Owen, Messrs. J. B. Sanders and Co., electrical engineers, brought an action against Mr. J. H. Insole, of Ely Court, to recover £23. 2s. 9d. The claim was £17 for laying gas pipes from the main to within Mr. Insole's premises to the gas engine which was laid down by the plaintiffs for the purpose of driving a dynamo. A contract was put in in which the plaintiffs undertook to supply all necessary plant for giving Mr. Insole an electric installation of 75 lights of 16 c.p. for £950. This sum had been paid, together with other moneys for extras admitted by Mr. Insole. On the claim £4 was paid into court for some of those extras which had been overlooked. The remaining part of the claim was £4 for a voltmeter and £16 for the gas mains. His Honour was of opinion that the mains and the meter were necessary for a complete installation, and were covered by the contract. He gave judgment for the plaintiffs for the amount paid into court, and ordered them to pay defendant's costs from the time the moneys had been paid in.

Lynton.—A special meeting of the Lynton Local Board has been held (Mr. Heywood presiding) to consider Mr. Benn's proposal to dispose of the electric lighting works to the Board for a rental of £193 per annum. A letter was read from Mr. Evan B. Jeune, stating that in a general way he was in favour of local authorities having control of lighting. In the present case he could not say that he had had time to form a definite opinion. If (1) the agreements made with Mr. Benn were of a favourable nature towards the supply of electric light; (2) the machinery efficient for the amount of light now in use; (3) there was no probability of any great outlay for renewal or repair of machinery at an early date; (4) the present revenue equals or exceeds the expenditure; and (5) that an agreement to manage for not less than three years, renewable afterwards from year to year, be made with some duly qualified person, recommended by an electrical engineer, he (Mr. Jeune) would be in favour of taking over the works. He considered the time given was short, more especially as members of the Board were not experts, and had no outside expert to rely on. The letter also stated that Miss Lock-Roe would not consent to more water being taken from the Lyn than at present. After considerable discussion it was resolved that a meeting of the ratepayers should be held to consider the advisability of acquiring the electric light works.

Newport (Mon.).—Alderman Davis proposed at a meeting of the Town Council this week, that application should be made to the Local Government Board for sanction to the borrowing of £28,000, under the powers of the Electric Lighting Act, 1882, repayable in 30 years, for the purpose of providing a supply of electricity in the borough. This proposition was seconded and carried. The Electric Lighting Sub-Committee of the Parliamentary Committee reported

that they had received the preliminary report of Mr. Robert Hammond, the electrical engineer, upon the proposed installation of electricity works, and it was laid on the table for the information of the committee. The proposed site selected for the central station is upon land in Friars Fields, entered from Union court, and Mr. Hammond considers it most advantageous in many respects, more especially as it will be easy to obtain a siding from the railway across Canal parade running into the yard for the supply of coal. The estimated expenditure, including the mains and arc lighting, of the installation for the western district of the borough, is £25,000. The report had been considered by the sub-committee, and some modifications in the proposals suggested. In the meantime it is recommended that the sub-committee should be authorised to request Mr. Hammond to proceed with the preparation of the detailed plans and specifications, in order that tenders may be obtained at the earliest possible date. The report was adopted.

Rochdale. – On the minutes of the Health Committee submitted to the Town Council last week, Councillor Diggle asked the chairman whether the committee were satisfied with the installation of electric light at the sanitary works, and whether their engine power was large enough to provide electricity for the Town Hall and neighbouring premises. Councillor Hardman replied that the plant had worked without a hitch. The supply was constant and regular, and satisfactory in every way. As to whether their power was sufficient for the suggested extension, he should like to know what the "other premises" were before committing himself. They had quite enough power for supplying the large hall, so far as the engine was concerned. Councillor Diggle said he had the Technical School particularly in mind. The other evening there were 75 gas lights burning in the chemical laboratory, and in spite of the ventilation system the room was as hot as a stove. It would be to the interest of the Corporation to supply both the Technical School and the Town Hall with electric light. They had spent a good deal of money in decorating the hall, and it would be a pity to spoil the room with gas. Councillor Cunliffe agreed as to the desirability of using electricity for lighting not only the assembly-room of the hall, but also the offices, where a large number of clerks were at work. The patent for incandescent lamps would expire in November, and already they were offered to users at less than half the former price. Electric light in the Town Hall would be a decided boon. The Mayor reminded the Council that they came to a decision on this matter a short time ago, and that there was nothing in the minutes to justify its reintroduction now. The minutes were confirmed.

Bristol. —When the adoption of the general district rate was discussed by the Town Council a few days ago Councillor Pearson said with regard to the electric light the machinery was for 100 arc lights only, and 96 had been put up. The incandescent lights were to be 10,000 16 c.p. lamps. Now it was evident that the street lighting could not be extended at present, and they could not go to Bedminster, for example, without putting a sub-station there for transforming. Certain slight extensions had already been granted. With regard to the incandescent lamps, it was calculated that only 60 per cent. of the lamps were alight at the same time in residential districts, so that there was some room for extension; but in Bristol the area to be lighted was a shoppy one, and therefore the number of lamps in use at the same time would be greater than in a residential district. Councillor Ashman said Mr. Pearson's answer was not at all satisfactory. They were told, when this matter was before them two years ago, that this was the first installation, and that cables would be carried to the bottom of Union street and the Croft as soon as possible; but they must be surprised to learn for the first time that this was impossible in regard to extending the light to Bristol North, and that if Bedminster needed the light they would have to have a station there. Councillor Pearson said Mr. Ashman quite misunderstood him. If they needed the light in Bedminster it would have to be transformed at a sub-station there, and delivered to the houses. If the demand for the light increased, they would have to enlarge their works at Temple-backs. They had now certain power at that station, and if more was needed they would have, as in other such undertaking, to extend their works.

Whitehaven. The minutes of the Electric Lighting Committee of the Town and Harbour Trust, presented at a meeting last week, included the following: "11th September. Read correspondence between surveyor and Dr. Hopkinson. The surveyor submitted account which he had received from the Furness Railway Company for expenses incurred by them in providing a special watchman while the electric cables were being laid under the Coach road level crossing. The committee do not admit any liability for the same. The surveyor reported on the progress of domestic lighting. 18th September. The surveyor was instructed to make arrangements for laying cables to Messrs. Pattinson and Winter's works, Barracks road, by way of Scotch street and Irish-street. The clerk was instructed to write to the Lowca Engineering Company, Limited, calling their attention to sundry defects in the new boilers, and requesting them to remedy such defects, otherwise the committee would be obliged to take steps under the powers of the contract." The Chairman moved the confirmation of the Electric Lighting Committee's minute. With regard to the lighting of the harbour, the mains were all laid and everything was ready, except that they were kept waiting for lamp fittings, which had not yet come to hand, for some unaccountable reason. It was to be hoped that within the next week they would be here, and the work would be so far finished that they would be able to turn the current on to the harbour. Mr. Hastwell seconded the motion, which was agreed to. The seal of the Board was affixed to a bond for £300 lent by a private individual for six years at 3½ per cent., this taking the place of a like amount of bonds at present held by the Cumberland Union Bank at 4 per cent.

Grimsby. –A meeting of the Electric Lighting Committee of the Town Council was held last week, Alderman Palmer occupying the chair. The members of the committee were each supplied with information respecting the cost of the electric light as introduced in many large towns. The report had been compiled by the borough surveyor (Mr. M. Petree) at the request of the committee. At Bradford there were 22 miles of mains for the electric light, and the whole cost £40,750. The current was sold at 5d. per unit, and the motive power cost 4½d. per B.T. unit. In Hull the cost of the works was £3,000, and the driving machinery £4,060, mains £10,000 (for 1¾ miles first laid). The charge was 7d. per unit, and motive power 6d. per B.T. unit. Mr. Nutt noticed that Scarborough had been omitted from the list of towns. Anyone who had visited it must have noticed the large amount of electric light in use for lighting private and public shops. At the hotel he stayed at this summer, whilst at Scarborough, the proprietor, in answer to questions, said that the cost was treble that of gas. The borough surveyor pointed out that in the case of St. Pancras the cost was three times that of gas, but the illuminating power was 10 times as great as gas. In a town of 32,000 inhabitants where the electric light had been adopted, the cost was greater than gas, but this was compensated for by better lighting. The Chairman moved that the committee recommend the Council to apply for a provisional order as a protection against electric lighting companies coming into the town and obtaining a monopoly. The resolution also was to appoint a sub-committee to go fully into the matter and get estimates from one or two contractors, so as to gain an idea as to the probable cost of the thing. He pointed out that if they got a provisional order they need not be compelled to carry out an electric lighting scheme if they did not see fit to do so. This proposition was duly seconded and carried.

Cardiff. –At a meeting of the Cardiff County Council on Monday Mr. H. White again called attention to the defective supply of gas and defective burners. He asked whether anything had yet been done in the matter. The Mayor said he was sorry to tell them they could not come to any arrangement with the gas company. Mr. White proposed that the Lighting Committee be asked to furnish a detailed report of the present situation of things, so far as the respective rights and responsibilities of the Corporation and the company were concerned, which should be furnished to individual members of the Corporation. Alderman R. Cory seconded the resolution, and said if the gas company would not treat them with courtesy and civility let them go to Parliament for powers. Mr. W. Lewis asked when the electric light would be supplied to the town. The Mayor said it might be in about 10 years' time, but it would be a very expensive thing. They were now supplying a limited area, which would come into operation in March next. This, however, was only intended for street-lighting. To supply all the streets and lanes would be a very expensive affair. As he argued four or five years ago, they ought to have purchased the gasworks, and if they had done so when they had the chance they would now be saving about £3,000 a year to the rates. He, however, was opposed by some people, and this was how the thing turned out. Electricity was a better light, but they could not do without gas. The minutes of the committee were then confirmed. At Cardiff County Council on Monday, the Town Clerk reported as to the proposed agreement between the National Telephone Company and the Post Office, and Alderman Carey stated that the Glasgow Corporation had applied for power to establish a municipal telephone system. He suggested that they should write for a copy of the Glasgow Bill, and if it was thought advisable they could apply for similar powers. On the Continent persons could obtain telephonic communication for something like £5 or £6 a year, and if this could be done in Cardiff it would be very advantageous to tradesmen and others. The suggestion was agreed to.

Accrington. —The town clerk has reminded the Legal and Parliamentary Committee that he had received the Local Government Board's sanction for the borrowing of the money for the purchase of the land for the baths and electric light station, and he has been instructed to prepare the necessary documents of transfer, and arrange for the completion of purchase immediately after the 12th November next. On the minutes being proposed for confirmation at a meeting of the Town Council last week, Mr. Sprake said he thought the Council was not quite aware of the importance of the matter. So far as he could see they were taking over the land on which the baths were built, and this, he thought, was a matter that was worth a little more consideration. When the site for the electric light station was selected there were several sites submitted for the consideration of the persons who came to inspect the district and this was chosen as the best. Since then, however, the Corporation had entered into arrangements with the gas and water company, and he believed it was intended to practically do away with the present gasworks in Hyndburn road, and use more of the works at Great Harwood. If that was so, the Corporation might be able to arrange matters in such a way that the electric lighting station might be fixed somewhere down Hyndburn road. The electric light was not an absolute necessity at present. There had been no outside pressure brought to bear upon the Corporation, and in the face of the large undertaking the Corporation had entered into with regard to the gas and water works, he thought they ought to proceed slowly in this matter, and not incur further enormous responsibilities. They were rapidly increasing the rates, and were face to face with an expenditure of some thousands of pounds in connection with the

sewage of the district—a burden that would fall upon the ratepayers. In the face of this, he did not think the Corporation were doing wisely in undertaking the responsibility of carrying out the electric light, and particularly baths at this stage. There was no pressing necessity for the Corporation entering into these undertakings, and he moved that the matter be referred to the General Purposes Committee—not with the idea of defeating the ultimate object the committee had in view, but in order that the subject might be more fully considered, seeing the great amount of money there was at stake. Mr Dewhurst seconded Mr Sprake's amendment. Mr. Riley quite differed from Mr. Sprake respecting the electric light. He thought the supply of electricity for lighting purposes was just as requisite as the supply of gas. If he was not mistaken the baths were self supporting, so that there would be no loss in connection with that undertaking. The Council might have noticed that rapid strides were being made in Manchester with regard to the electric light, and that ought to satisfy them as to the wisdom of adopting the light. He thought they had gone too far now to stop in the matter. Mr. Sprake said no outside pressure was being brought to bear, but he said there was. Several persons had asked him what had become of the electric light scheme, and the answer he had given was that the matter had been allowed to lie in abeyance owing to the work the Council had on hand with reference to the gas undertaking. He thought that now the electric light ought to go on just as well as the gas question. After further discussion, the amendment was rejected, and the minutes were confirmed.

Yeadon.—A public meeting of ratepayers has this week been held for the purpose of considering the advisability or otherwise of adopting a system of electric lighting. The chairman of the Local Board (Mr. James Flaxington), who presided, said that the Yeadon Gas Company had given them fair satisfaction both as to price and quality of gas supplied. The electric light, however, was making such progress that the Local Board had come to the conclusion, after thoroughly investigating the matter, that it would be to the interest of the ratepayers to adopt that system of lighting for Yeadon. They had therefore called the ratepayers together to consider the matter. Messrs Andrews and Preece, of Bradford, had submitted a scheme to the Board, and guaranteed that they could furnish electric light—allowing for cost of labour, fuel, interest on capital, etc.—at 4d. per unit, which was equal to gas at a cost of 1s. 6d. or 1s. 7d. per thousand cubic feet, whereas they were really paying at Yeadon 2s. 11d. per 1,000ft. net. The electric light was, therefore, much cheaper than gas, and it was, in addition, a better illuminant. It was proposed to charge 10s. per lamp per annum for the electric light, and there would be no restriction as to the length of time the light was used. Mr Preece, in explaining the scheme proposed by his firm for adoption, said that they were enabled to supply the electric light at the price named by the chairman through the fact that they used Dowson's gas system and gas engines, which reduced the cost of fuel to one third the cost where steam engines were used. At Morecambe, where their system had been in operation some time, the company had—with a charge of 10s. per lamp per annum—been able to pay a dividend of 5 per cent. on the first year's working. In answer to questions, Mr. Preece explained that the kind of gas they manufactured in connection with the generation of electricity was totally different from coal gas. They had to make 4,000 cubic feet for 1,000 cubic feet of ordinary town's gas, but it cost them only 2d. per 1,000. After the 10th of November next the cost of incandescent lamps would be reduced from 3s. 9d. to 1s. Notwithstanding the higher price for the lamps, they had been able to give every satisfaction with the light at Morecambe, and to make the dividend he had stated; while consumers said that their lighting bills were greatly reduced. Mr Thompson Marshall (a member of the Local Board) said that by adopting the electric light they would not only get a better illuminant at a cheap rate, but they would have other advantages in the prevention of dust and danger. The benefit on the score of health would be very great. The members of the Board who had been to Morecambe visited a large number of houses and other buildings indiscriminately, and they were invariably told that the light was good and as cheap, or cheaper, than gas. Mr Bernstein urged that it was an erroneous idea that electricity was simply going to oust gas altogether. It had been found in nearly all places where electric lighting had been adopted that the consumption of gas had increased. Engineers were constantly inventing new appliances in which gas was used, and doubtless that would go on. Mr H. Marshall and Mr. E. M. Chippendale, members of the Local Board, both spoke in favour of the scheme, the latter pointing out that while their 107 lamps cost £1. 14s. 1½d. per annum each in wages and gas, the same number of electric lamps at 10s. each would mean a saving of about £130 a year. It was also pointed out that this and any other monetary advantage accruing from the adoption of the electric light would go to the reduction of the rates. Eventually a resolution was adopted to the effect that the ratepayers were satisfied with the scheme, and that the Local Board should take proper measures for obtaining full lighting powers.

The Reduction in the Price of Lamps.—In the course of an article on the impending expiration of the incandescent lamp patents, the *Financial News* says: "To come down to a practical illustration of the effect of the fall in price, it may roughly—very roughly—be reckoned that it would cost about £70 to wire a house of average size for, say, 50 electric lamps and to supply the necessary plain fittings. The 50 lights would, under the old price, add £9. 7s. 6d. to the price, making it amount to £79. 7s. 6d. With Ediswan lamps at 1s. 6d. each—as already stated, they have not yet reached this figure—the cost would be £73. 15s., showing a reduction of £5. 12s. 6d. This is satisfactory; but the saving is to be seen more clearly in the cost of renewals. The fittings and wiring last, of course, for years, and do not require to be replaced until they show signs of wear; but the incandescent lamps must be renewed at intervals. Each lamp is calculated to burn for about 1,000 hours, its life being measured by the ability of the carbon filament to keep itself together. Allowing that each lamp is alight for three hours each day, its period of existence is one year, and there must consequently be an annual renewal. If they are run properly, the lamps might last for three or four years, while if they are not treated well the filaments might give out in six months; but 12 months is the average life. The cost of renewal, therefore, will be reduced from £9. 7s. 6d. a year to £3. 15s. a year, so that there is considerable economy as regards this item. Unfortunately, the use of the electric light is restricted to some extent by the fact that householders on short leases are disinclined to face the heavy initial outlay on installation. Where the tenant is also landlord the matter is different, but the tenant on a short lease declines to spend a heavy sum on a house which he may have to vacate in a few years, while his landlord usually refuses to bear the major part of the cost. But notwithstanding such drawbacks as these, the electric light—which must for some time to come be called the rich man's illuminant—is bound to become more popular, and the freer use of it will, of course, enable the various supply companies to furnish the necessary current at a reduced rate. Comparisons of the cost of the electric light and of gas, highly favourable to the former, are often made, but in the case of such experiments there is, no doubt, an exceptionally cheap supply of power. It may be taken as a fair basis, and one on which reliance can be placed, that where the charge of the company supplying the current is 8d. per Board of Trade unit—the usual rate—the electric light would cost the same as gas if the latter were supplied at 6s. 9d. per 1,000ft. Hence, if gas is at 2s. 3d. per thousand, the electric light is three times as expensive, and it is twice as costly where gas is at 3s. 4½d. per thousand. It has been pointed out that, in view of the advent of cheaper lamps, consumers may prefer to select lamps of less candle-power than they require and to increase their efficiency by 50 per cent.—*i.e.*, run a lamp of 8 c.p. at 12 c.p. In this way the life of the lamp would be shortened by about one half, and the cost of renewal might be doubled; but the lamps would be cheap, and there would be a considerable saving in regard to the amount of current used. Of course, the lapse of the incandescent lamp patent must affect the position of the Edison and Swan United Electric Light Company; but it will, nevertheless, continue to do a fairly profitable business. As Mr. James Staats Forbes said at the meeting two months ago, the Edison and Swan Company can make lamps as cheaply as an English firm, and probably as any foreign manufacturers. This is due to a large extent to the fact that the company keeps its process of manufacture as secret as possible, and this remark applies especially to the composition of the carbon filament and to the method of exhausting the glass bulb of air. Besides this, it holds many valuable patents as regards electrical fittings, and it has sole rights as regards a lampholder retailed at 1s. 8d., which is almost universally used. As the company does not permit the manufacture of these holders by others except at a heavy royalty, it follows that a consumer of the electric light must either purchase Ediswan lamps or must go without the advantages attaching to this holder. This fact gives the Edison and Swan Company a long pull over its competitors, and will ensure a demand for its products until the holder patent expires. Years ago the company acquired the British rights of the Swan United Electric Light Company, and negotiations are proceeding with a view to the taking over of the remnant of the business—all, of course, foreign—of the latter concern. There may yet be further patents granted in respect of a lamp on the principle of the Ediswan. It is confidently predicted that before very long a lamp will be invented having its filament so constructed that it will give a good light with a consumption of two-thirds of the amount of current at present used. It is mainly the filament which must be improved; for the vacuum will apparently continue to be used in any case, and lamps possessing no vacuum, with a platinum or other filament, have all been comparative failures. When lamps consuming only two-thirds of the present necessary quantity of current are invented the cost of domestic electric lighting will be reduced by one third, and another great development in the industry will be brought about."

Lighting at Taunton.—As mentioned in our last issue, a meeting of the Town Council was held on the 2nd inst., when the Electric Light Committee presented the following report: "Your committee report that they have reconsidered the subject of supplying electricity to Salisbury House, Billet street, and, as the matter was pressing, they have arranged, with the consent of Alderman Van Trump and Councillor Stevens, to extend the overhead wire through these gentlemen's premises, and to carry it underground across Billet street, at a cost not exceeding £20. They have also received an application from Mr. A. Steevens to supply Osborne House with electricity, which they have agreed to do, subject to Dr. Fleming's advice as to the best mode of carrying out the extension. Your committee recommend that as the present charges for arc lamps are remunerative they shall remain as at present, subject to three months' notice of alteration on either side. Your committee have instructed the town clerk to see that the agreement with Messrs. Laing, Wharton, and Down is cancelled. Your committee have had an interview with Dr. Fleming, who will report fully on various subjects when he has considered the information which he has obtained from the officials. The committee ask for leave to carry out any pressing works at a cost not

exceeding £50. Your committee present the contract with the electric light company for the purchase of their works, and they recommend that it shall be sealed with the common seal of the borough." Councillor Potter, the chairman of the committee, moved the adoption of the report. He reminded the Council that at the last meeting the proposal to lay on the light to Salisbury House was referred back to the committee. The committee met the next morning as the case was urgent, and as a result of their deliberations they decided to carry out the work at a cost not exceeding £20. Arrangements were made with Mr. Van Trump and Mr. A. Steevens to run the wire along their garden walls and take the cable across the top of Billet street. This had been done. At the last meeting it was estimated that 15 or 16 lights would be required at Salisbury House; the actual number installed was 20, and thus the revenue would be greater than was anticipated. An application had also been received from Mr. A. Steevens to supply Osborne House with the electric light. In their interview with Dr. Fleming, he suggested various things to the committee, but they had received no definite instruction, because he desired to consider the whole question—the economical working of the light, the suggested extensions, etc. For that purpose he requested that a map of the borough should be sent him, with other information which he sought from the borough surveyor. All that had been done and he was now considering the whole position, and would give them a report advising them as to what would be the best things to do. The committee had agreed to make the extension to Osborne House, subject to the approval of Dr. Fleming. The number of lights required would be about 50. As the Council would be compelled to put the wires underground within two years, it was thought best to put the cable at once underground along Upper High street. The wire for incandescent lighting extended no further than Dr. Iles's house, and the proposal was to extend the incandescent wire from that point to Osborne House and put the whole underground. The incandescent cable could then be used for street lighting. There were three gas lamps in the street, and an incandescent lamp could be placed on one of them. That would tend to increase the income. The committee recommended that the present charges for arc lamps should not be changed, for one or two reasons. It was thought that some of the arc lamps would be thrown out in favour of incandescent lights, and it was not desirable to fix meters for arc lamps. And as it was carried on at a price which entailed no loss to the Council, it was thought desirable not to interfere with the arcs at present. That arrangement would be subject to three months' notice on either side. In compliance with the wish of the Council, the committee had instructed the town clerk to see that all agreements with Messrs. Laing, Wharton, and Down were cancelled, and he believed that had been done. The committee asked for permission to carry out any work not exceeding £50 in cost. The committee did not ask the Council to empower them to spend money to the extent of £50 without bringing it before the Council if they had an opportunity of doing so, but only in the case of urgency, such, for instance as that of Salisbury House, when it would not be convenient to defer the carrying out of the work until the meeting of the Council. If the works were to be carried to a successful issue the Council must give some power to the committee in this respect. The committee presented the contract for the purchase of the works, which had been drawn up by the town clerk, on behalf of the Council, and Mr. Kite on behalf of the company. The contract had been submitted to counsel, and in its present form had received counsel's approval. Councillor Hammett seconded the adoption of the report, which, with the exception of the recommendation as to Osborne House, was adopted. At a monthly meeting of the Town Council on Monday a long discussion took place on a charge of the town clerk's amounting to £135, made in respect of legal work done by him in connection with obtaining the electric light license and provisional order. The Town Clerk (Mr. T. Meyler) stated that all the charges were strictly accurate, and he could substantiate them before any taxing master. The account was passed. The Electric Light Committee were empowered to procure a new boiler for the works.

PROVISIONAL PATENTS, 1893.

OCTOBER 2.

18386. **Improvements in electrical switches.** Edward William Lancaster, Albert Works, Graham-street, Birmingham. (Complete specification.)

18392. **Improvements in electric clocks and watches.** William Walter Gerald Webb, 9, Coppenhall-terrace, Crewe.

18403. **Improved means of intercommunication by telephone.** John James Mann, 4, St. Ann's square, Manchester.

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18428. **Improvements in electric telegraphs and mechanism used in connection therewith.** George Draper and Angus Fraser, 24, Southampton-buildings, Chancery-lane, London.

OCTOBER 3.

18457. **Electrically-lighted letters.** Henry Hawksey, 6, St. John-street, Deansgate, Manchester.

18460. **Improvements in armatures for dynamo-electric machines and electric motors.** Martin Rahner, 34, Southampton-buildings, Chancery-lane, London. (Complete specification.)

18475. **Electric signals for railways.** Arthur Moore Thompson, Crewe Works, Crewe.

18482. **Means for determining the presence and intensity of atmospheric electricity.** Jesse Opperman, 55, Chancery-lane, London. (Complete specification.)

18524. **Improvements in indicators chiefly designed for use at telephone stations also used for advertising purposes.** Ignatius Raleigh Burns and Walter Francis Burns, 45, Southampton buildings, Chancery-lane, London. (Complete specification.)

18530. **Improvements in the arrangements and connection of conductors for electric railways.** Siemens Bros. and Co., Limited, and George Herbert Thornton, 28, Southampton buildings, Chancery-lane, London.

OCTOBER 4.

18586. **An improved regulator for arc lamps.** Leon Zausmer, 6, Lord street, Liverpool.

18596. **Improvements in the means or mode of protecting insulators as employed for electrical purposes or appliances.** William Martin, Victoria-chambers, Martineau street, Birmingham.

18602. **Improvements in telephone switchboards.** Charles Denton Abel, 28, Southampton-buildings, Chancery lane, London. (Société Générale des Téléphones, Reseaux Telephoniques et Constructions Electriques, France.)

18609. **Improved telephone attachment.** James Gilbert Foster, 55, Chancery lane, London.

18610. **Improved electrical heating apparatus.** Percy Richard Julius Willis, 55, Chancery lane, London. (Charles E. Roehl, Sidney Z. Mitchell, and Earl P. Whetmore United States.)

OCTOBER 5.

18626. **Improvements in electrical conductors.** John Baragwanath King and Thomas Edwin Bickle, Great Western Docks, Plymouth.

18661. **Improvements in electric telegraphs for steering, engine-room, and other signalling purposes.** Frederick George Panizzi Preston, 77, Chancery lane, London.

18674. **Improvements in electrical receiving instruments and relays.** The Phonopore Company, Limited, and Charles Ernest Spagnoletti, 28, Southampton buildings, Chancery-lane, London.

18690. **Improvements in conduits for electric conductors.** Charles Gordon Picking, 47, Lincoln's-inn-fields, London.

OCTOBER 6.

18734. **Improvements in electric meters.** Hans Peter Olsen, 46, Lincoln's inn-fields, London.

OCTOBER 7.

18805. **Improvements in electric measuring instruments.** Benjamin Davies, 6, Lord street, Liverpool.

18841. **An improvement in incandescent electric lamps and sockets.** The Edison and Swan United Electric Light Company, Limited, and John Ambrose Fleming, 28, Southampton buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1892.

14124. **Electromotors.** Hurd. (Second edition.)

16335. **Electric telephonic apparatus.** Harrison.

16615. **Electric incandescent lamps.** Froggatt.

17653. **Electric batteries.** Lohman.

20415. **Microphones.** Gent and others.

21782. **Electrical resistance coils.** Siemens Bros. and Co., Limited, and Nobel.

1893.

5094. **Electrolytic decomposition of solutions of chloride of sodium, etc.** Richardson.

13888. **Electric current, etc., governors.** Wiese.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¼
Charing Cross and Strand	—	[illegible]
City of London	—	11½
— Pref.	—	13
Electric Construction	—	1¾
House-to-House	5	2½
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¼
London Electric Supply	3	1
Metropolitan Electric Supply	—	7
National Telephone	[illegible]	4¾
St. James, Pref.	—	8½
Swan United	3¾	3¼
Westminster Electric	—	5½

NOTES.

The Madras Tramway.—Work in connection with the erection of the generating station has been commenced.

Cork.—A large arc lamp has been placed outside the Munster arcade, Patrick-street. It is the only public arc lamp in the town.

The "Revenge."—This battleship is lighted by 700 electric incandescent lamps, and there are also four very powerful search-lights.

Piezo Electric Pile.—The paper read last week by Lord Kelvin before the French Academy of Science dealt with a piezo electric pile.

Vienna.—The Berlin Electrical Company is reported to have obtained the concession for all the electric tramcar lines to be constructed in Vienna.

Taunton.—A correspondent suggests the utilisation for the production of the electric light of the water power at the weirs at each end of the town.

Madrid.—A system of electric tramways is to be introduced in Madrid, a German electrical company being largely interested in the enterprise.

The Seine.—The Service de Sauvetage of the Seine has in use a system of electrical communication between the salvage points and the central office.

Milan.—An electric tramway on the Thomson-Houston system, between the Piazza del Duomo to Porta Sempione, will be set in operation in a few weeks.

Police Lamps.—Experiments are being made with hand electric lamps for the Dundee police force, and it is possible that some such type of lamp will be adopted.

Baltimore.—A fire caused at the Brush electric light station by two wires becoming crossed has resulted in heavy losses to the company and in the burning down of a gaol.

Bradford.—On Monday, Mr. J. W. Riley, D.Sc., delivered before the Bradford Scientific Association an address on "Central-Station Systems of Electric Lighting."

Personal.—We regret to learn that Prof. Helmholtz met with an accident on the voyage from the United States to Bremen, and that it has necessitated his removal to hospital.

An Electric Chronograph.—An electric timing apparatus, invented by Sterling Elliott, has been officially recognised by the Racing Board of the League of American Wheelmen.

Regent-street Polytechnic. — A course of 30 lectures has been commenced at the Polytechnic Institute, Regent-street, W., in electrical engineering and experimental physics.

The Double Event.—See the daily papers of Monday and the *Pall Mall* of Thursday—first and second blows—viz., Harness goes for £55,000 new issue; the *Pall Mall* goes for Harness.

The Institution Annual Dinner.—The annual dinner of the Institution of Electrical Engineers is to take place on Wednesday, the 22nd November, at the Freemasons' Tavern, Great Queen-street, W.C.

Lighting in Berlin.—At present there are in Berlin about 160,000 incandescent lamps of 16 c.p. energised from the network of the Berlin Electricity Works. The company have introduced several systems for automatically indicating faults.

Small Motors.—Electromotors of powers ranging from $\frac{1}{25}$ h.p. to $\frac{1}{8}$ h.p. are being introduced by Messrs. Bauer and Betz, of Berlin. They are on the "Betz" system, and are intended for use in houses and for small industrial operations

Telephony.—Instructions have been given for the immediate laying of cables between the shore and the Kentish Knock and North Goodwin Sands lightships for telephonic communication, so that the work may be done before the winter sets in.

Station-Lighting.—As mentioned in a previous issue, the Great Northern Railway Company have for some time past been engaged on the lighting by electricity of the King's Cross Station. The work is now nearly completed, and in addition to the station, the hotel is being electrically equipped.

Wilhelm Weber.—The Royal Society of Science at Göttingen has published the works of Wilhelm Weber, who was at one time professor at that university. The name of Weber is well known in the world of science. Weber's writings have now been collected into five volumes, edited by the Scientific Society of the university.

Edinburgh.—The deputation of seven members of the Town Council to various cities in England on the subject of electric light, and which was absent for eight days, cost £173. 10s. The Town Council have confirmed the minutes of the special meeting held last week resolving to lease the tramways to Messrs. Dick, Kerr, and Co.

Train-Lighting.—The success attending the working of the electric light on their trains has induced the directors of the London, Brighton, and South Coast Railway to give instructions for 10 additional trains to be equipped with it. When these are running, the company will then have 40 trains to which this mode of lighting has been applied.

Wind Power.—M. de Rufz, of St.-Lunaire, has lighted his residence by electricity, the power being obtained from a windmill of the "Eclipse" type. The windmill is arranged on a masonry tower at a height of 33ft. from the ground, and the power is transmitted by gearing and belt to a dynamo which charges accumulators from which 25 incandescent lamps are energised.

Phonographs and Ear Diseases.—The attention of the authorities has been called to the fact that danger lurks in the phonographs which are in public use in various parts of the town. It is submitted that in America these instruments caused diseases of the ear to largely spread, and that it became necessary to compel each exhibitor to cleanse by acids the tube after individual use.

Traction at Newcastle.—A sub committee of the Tramways Committee of the Corporation has been appointed to meet the members of a syndicate and discuss details as to proposals made for the running of the trams by cable on the different lines in the city, and for the doubling of the whole of the single lines, and to extend the tramway system. Is there any chance for electric traction?

The French Transformer Action.—As a result of the action which they gained over the Compagnie Internationale d'Electricité de Tours, and to which reference was made some weeks ago, Messrs. Zipernowski, Deri, and Blathy have caused to be seized the transformers of the Thomson-Houston and Ferranti type used by the Société l'Energie Electrique at Havre. It is said that a further action on the matter will be entered upon.

Economy in Fuel.—Mr. Riley, in a paper read before the Royal United Service Institution, considers that the principal direction in which to look for economy in the consumption of coal on board ship is in the auxiliary engines, particularly those used for electric lighting purposes.

He mentions that the "Warspite," on passage to her station, charged four tons per day for lighting purposes, which, after arrival, was diminished to three tons and less.

South Staffordshire Tramways.—These tramways continue to attract a good deal of attention. M. Gerrard, Chief Minister for Railways, Telegraphs, and Post Offices for Belgium, has paid an official visit on behalf of the State authorities of his country and made a complete examination of the line and installation. Then the mayor and town clerk of Leeds have made a like visit and inspection, and reported so favourably that the entire Corporation has since made an examination.

Lightning Conductors.—According to a note by M. Precht, the discharge from lightning conductors can only be produced when the potential reaches 15,009 volts. Even very fine points can be charged up to 25,000 volts before giving a continuous discharge. The presence of large quantities of dust or of gas round the points renders the discharge more difficult, whilst the ultra-violet light facilitates it. A group of points can be charged at a higher potential than a single point.

Frankfort-on-the-Maine.—The Town Council has adopted the proposal of the Executive Department for the erection of municipal electric light works, according to the plans submitted by Messrs Miller and Lindley, on the alternate-current system with transformers, and a low-tension distributing network. Messrs. Brown and Boveri, of Baden, Switzerland, have been entrusted with the construction of the alternators, and Messrs. Felten and Guilleaume, of Cologne, with the supply of the cables.

Electrical Laboratory.—An electrical laboratory has been opened in Paris by the Société Internationale des Electriciens, a former president of this society, the president of the Syndicat des Industries Electriques, and a delegate of the municipality. Lectures are to be arranged, and systematic investigations into questions connected with electricity will be made. Apparatus will be tested and experiments made for the public, and under certain conditions persons will be admitted to make tests and conduct investigations on their own account.

Liquid Fuel.—Mr. F. J. Hadfield, in dealing with the coal strike as an economic error of the gravest kind, has no hesitation in saying that steam users are at the present moment wholly independent of coal, and that it only needs a little further pressure to ensure the market being inundated with crude petroleum and aslatki, both of which products can be very successfully used for heating purposes and the manufacture of gas. Having obtained steam alone, electricity, he states, can do all the rest. This he hopes will serve as a warning both to masters and men.

Traction at Leeds.—It is interesting to note that the Highways Committee of the Corporation have decided to renew for six months the lease of the line for the working of the electric cars to Roundhay Park, and after that for an ensuing period of one month at a time until a final decision is arrived at. As mentioned in another column, the Highways Committee have inspected the Walsall electric cars, and a special meeting of the committee will shortly be held to consider the subject of traction on the whole of the Leeds tramways.

The Fatal Accident.—The Board of Trade was represented on Monday at the adjourned enquiry into the circumstances attending the death of F. W. Ball, who was killed at the Blackfriars-road transformer station of the London Electric Supply Corporation on the 12th ult. The facts of the case were given in our issues of the 15th and 22nd ult. Further evidence was given, and the enquiry was again adjourned until the 16th January, to allow of the jurymen to visit the station, and for E. Meach, who was injured at the time of the accident, to be able to attend.

The German Accumulator Action.—Judgment was pronounced on Wednesday against the plaintiffs in the action brought by the London Electric Power and Storage Company against the Pollak Company, the proprietors of the accumulator works in Frankfort-on-the-Maine, to restrain the latter from manufacturing or selling accumulators. This is the first time that a German court of law has given a different decision from that pronounced in similar actions against other accumulator manufacturers preferred by the actual patentee—namely, the Accumulator Manufacturing Company of Hagen.

The Tramways Institute.—A meeting of the General Council of the Tramways Institute of Great Britain and Ireland took place last week at the offices of the Birmingham Central Tramways Company. Mr. W. J. Carruthers Wain presided, and there were also present Messrs. J. Ebbsmith (chairman Birmingham Central Tramways), A. P. Smith (chairman Bury, Rochdale, and Oldham Tramways), R. Whittaker (chairman Southport Tramways), William Mason (director of the Bradford Tramways and Omnibus Company), and J. G. B. Elliott (secretary). Several matters of special interest to tramway companies were discussed.

Chicago Exhibition Awards.—The following awards are announced for the electrical exhibits: British Government Postal Telegraph Department, modern telegraphic apparatus in operation, and historical telegraph apparatus; Corporation of Birmingham, original Woolwich dynamo; General Electric Company, Limited, London, H I switches and other incandescent house fittings; James White, Glasgow, electromagnetic balances (Kelvin). In the transportation section, the London and North-Western Railway Company receive an award for the application of electricity to boiler-shop tools and for electric train staff apparatus.

A New Motor.—On Wednesday, Major-General Hutchinson, R.E., visited Croydon for the purpose of inspecting, on behalf of the Board of Trade, a new tramcar which is about to be used on the Croydon and Thornton Heath section of the Croydon and Norwood Tramways Company. It is known as the Lührig gas car, and is propelled by gas motors. It is said that from experiments made by Prof. A. B. W. Kennedy, F.R.S., it has been found that in ordinary circumstances the cost of traction will be reduced by about 65 per cent. The gas is ignited by an electric spark, and the motors consist of two double-action 7-h.p. gas-engines.

Fog-Signalling by Electricity.—In a recent issue we suggested the introduction by railway companies of a mechanical or electrical system of placing fog-signals on the metals. We are now glad to learn that the Great Northern Railway Company are extending on their North London branch lines the experiment of fog signalling by means of electricity. The method of working is simple, and is the invention of an electrician in the employ of the company. The system, which is in working order at Wood Green, has proved so satisfactory that the company have decided to fit up the suburban lines, and probably make further extensions at no distant date.

Steam to Aid Water Power.—The necessity for making some provision against the contingency of the river level falling considerably where the water power is used to operate turbines for electric lighting, is shown in the case of Toulouse. There the waters of the Garonne have fallen to such a large extent that not only have many industrial establishments in the neighbourhood been obliged to shut down, but the local electricity company, which usually has

four turbines at work, can now only operate one. This has necessitated a curtailment of the electric lighting, and it shows that auxiliary steam plant would have proved of great advantage in the emergency.

The "Volta" Lamp.—This lamp, which is to be introduced by the British Volta Electric Glow Lamp Company, of 49, Queen Victoria-street, E.C., on the expiration of the Edison patent next month, is claimed to have the high practical efficiency of 2·7 watts per candle-power. It is also asserted that with the "Volta" lamp the light does not fall off rapidly, that the bulbs do not become black, and that the current or voltage does not require to be raised to keep the lamps at their original brilliancy. The lamp will be manufactured of 8, 10, 16, and 32 c.p., ranging from 50 to 110 volts, and with, it is said, an efficiency of 2·7, 3, and 3·5 watts per candle-power as may be required.

The Russians at Toulon.—As Admiral Avellan, after quitting the "Formidable," entered the new harbour on his way to the arsenal, all the search-lights of the fleet were concentrated upon his boat. At the arsenal, in an enormous ballroom, a grand ball was given to the Russians by the officers of the French Army and Navy. Beneath the inclined, barn like roof was a temporary ceiling of bunting, and depending from it were six gigantic chandeliers formed of pistols and revolvers and bearing incandescent lights. A central chandelier, larger than the rest, was formed of 70 pistols, 30 sabres, and 25 pistol barrels, the last being mounted as candles, and each bearing an Edison lamp. There were also many arc lamps.

Electricity in Mining Operations.—In the course of his inaugural address on Saturday to the North of England Institute of Mining and Mechanical Engineers, Mr. A. L. Stevenson said that he doubted very much whether, for lighting purposes, electricity would be of much use to the mining engineer. No great light was required at the surface, but if the fire risks could be overcome, it might be of value in the cleaning and screening of coal. He said that many attempts had been made to produce portable miners' lamps, but, for his own part, he was so thoroughly satisfied with the safety of the lamps now in use, that he had not taken much interest in the attempts to solve the electrical difficulty. For the transmission of power beyond a thousand yards, electricity had proved its value, and the cost would, he hoped, be capable of reduction. Whether it was a suitable medium to be taken beyond the lamp station or the caution-board, those who adopted it, he remarked, must decide for themselves.

Stopping Generating Plant.—A method for stopping generating plant at a distance without the use of an extra wire has been devised by Mr. R. H. Postlethwaite, A.I.E.E., of Dunedin, New Zealand. The device consists of an electromagnet wound to carry the total current. When the plant is started a weight is attached to the poles, the weight being in communication with the turbine or water-wheel regulator either by a system of weights or cords and pulleys. As soon as the main switch is opened the magnet loses its power, the weight drops, and the gates are hereby closed. The magnet is designed so as not to let go until all the current is cut off. The last installation carried out with the use of this device was for a private residence, the turbine being about half a mile distant from the house. The weight when dropping first throws a governor out of gear and then shuts the turbine gates. The main switch is arranged in the owner's bedroom, so that he can shut down after retiring to rest.

Lighthouse Communication.—The Lord Mayor on Wednesday evening entertained at the Mansion House the Elder Brethren of the Trinity House and the Conservators of the Rivers Thames and Lea. Sir Sidney Webb, in the course of his reply to the toast of "The Trinity House," said that effect had already been given to some of the recommendations of the recent Electrical Communication Commission. Several outlying lighthouses on the mainland were now in direct connection by telephone with the postal telegraph system of the country. Telegraph cables had also been laid to Lundy Island and the Gunfleet Lighthouse. The Kentish Knock light vessel, 18 miles from land, and the Goodwin, five miles out, both important as look-out stations, the one for the Thames entrance, and the other for the trade route through the Straits of Dover, were about to be connected in like manner with the shore. For this particular work a special grant had been voted by Parliament, and the operations were being carried on in conjunction with the General Post Office.

Measuring the Efficiency of Dynamos.—In a note addressed to the Association des Ingenieurs-Electriciens sortis de l'Institut Montefiore, M. Felix Mélotte refers to the most generally used methods to determine the efficiency of electrical plant, and to the method which he employs to avoid heating of the band brake. At the Ecole des Mines in Belgium use is made of hollow pulleys, which receive a current of cold water, which afterwards passes freely away. This system is not directly applicable to the pulleys of electric motors, which on account of their great circumferential speed might have thrown the water violently on all sides. To avoid this, M. Mélotte inserts a bent tube in the opposite direction to that in which the motor is revolving, and in the interior of the pulley. The water introduced in the pulley is held on the felly by the effect of the centrifugal force, and takes part in its motion. When there is a certain quantity of it, its surface touches the tube, enters it, and passes out without a drop being lost. In this manner it has been possible to test a motor of 6 h.p. at a speed of 1,200 revolutions with a pulley 15cm. in diameter, and keep the speed for more than 10 minutes.

Electro-Harmonic Society.—The second smoking concert of the season will take place on Friday evening next, the 27th inst., at the St. James's Hall Restaurant, Regent-street, W., commencing at eight o'clock. The following is the programme: Part I: Madrigal, "What ho!" (Beale), Messrs. Lester, James, Kearton, and Miles; song, "I will Come" (F. H. Cowen), Mr. Albert James; pianoforte solo, "Rhapsodie" (No. 13) (F. Liszt), Mr. Alfred E. Izard; song, "When Bright Eyes Glance" (Hedgecock), Mr. R. E. Miles; violin solo, "Fantaisie—Scène de Ballet" (De Bèriot), Mr. T. E Gatehouse; recitation, Mr. Fred. Frampton; song, "The Sailor's Grave" (Sullivan), Mr. Harper Kearton; humorous sketch, Mr. James Kift. Part II.: Duet, violin and pianoforte, "Andante Rondo" (Kücken), Messrs. T. E. Gatehouse and A. E. Izard; old ballad, "I Lov'd the Maid for Loving Me" (G. W. Maddison), Mr. Albert James; song, "King and Slave" (F. Allitsen), Mr. R. E. Miles; violin solo (*a*) "L'Addio" (Schubert; transcribed by T. E. Gatehouse), (*b*) "Canzonetta," from "Concerto Romantique" (B. Godard), Mr. T. E. Gatehouse; Irish song, "Paddy O'Rafther" (Lover), Mr. H. Lester; recitation, Mr. Fred. Frampton; old ballad, "Tom Bowling" (Dibdin), Mr. Harper Kearton; humorous sketch, Mr. James Kift.

Massage and Galvanic Conduction.—In the course of a paper dealing with massage in diseases of the skin, Dr. A. Symons Eccles says: "Perhaps one of the most interesting effects of massage to dermatologists will be the influence which it has been repeatedly observed to exercise on galvanic conduction. This I have already noted in more than one of my previous papers; but in view of the possible value which may arise from the employment of the cataphoric action of the constant current in the treatment of skin diseases, it may not be out of place to refer

again briefly to the indisputable fact that massage greatly decreases the resistance of the uninjured skin to the passage of electrical currents. I have repeatedly observed that previous massage of a part will economise the number of cells necessary in order to pass a given number of milliamperes of current through the skin, and that whilst the same current may be maintained during the application the number of cells in action may be more rapidly reduced than is possible when massage has not previously been employed. I venture to suggest that if it is desired to use the alternating constant current for the purpose of percutaneous medication by saturating the electrodes with a watery solution of the substance selected for use, the preliminary application of massage may most probably be found to increase the rapidity with which the drug will be absorbed, just as it undoubtedly reduces the resistance of the tissues to the passage of the electric currents."

Electric Water-Level Indicator.—In the *Proceedings* of the Institution of Civil Engineers there is described an apparatus, designed by Mr Dieudonné, to indicate the water-level in a reservoir, boiler, etc., at any distance by means of electric signals conveyed by a telegraph wire. The float is connected by a cord to the edge of a circular sector free to turn on its centre, and the pull of the cord is counteracted by that of a dead weight, so that the angular motion of the sector always corresponds to the rise or fall of the float. The sector is of metal, and passes over in its rotation a number of metallic radial arms equally spaced. The electric current reaches these arms through the sector, so that in various positions of the sector different numbers of the arms are in the circuit. Another part of the transmitting apparatus is a semi-circle of ebonite, on which are a number of metal plates, each of which is separately connected by wire with one of the arms above spoken of. On this ebonite plate is a radial arm, which, when it revolves, successively touches each of the metal plates. At the receiving station, when it is desired to know the water-level, all that is necessary is to complete the circuit by pressing a button. Suitable electromagnetic apparatus then causes the radial arm to travel over the ebonite plate, and in doing so the circuit is made and broken for a number of times, which indicates the position of the sector and so of the float. A telephone is used to count the number of breaks in the circuit, and any degree of precision may be obtained by choosing the number of radial arms to correspond with any desired scale.

A T-Square Attachment.—The attachment consists of a bar provided with two slotted metal struts, secured to it by screws. This bar is placed against the working edge of the head or stock, and under the blade of any ordinary T-square, so that the struts lie on the upper surface of the head. By means of milled screws passing through the slots of the struts into plug nuts fixed in the head of the T-square, the bar may be securely locked at any desired angle to the blade of the T-square. It will be evident that if the T-square be now put in position on a drawing-board with the edge of the bar doing duty for the working edge of the head, the blade will have an inclination corresponding to the angle at which the bar is fixed. By means of this attachment any ordinary T-square may be converted so as to embody all the advantages of one having a movable head, and at the same time it will be found to be more rigid and less liable to get out of position. The attachment may be removed by taking out the two milled screws, when the T-square resumes its ordinary appearance. Should it be desired to make any additions to a drawing, or to make a tracing from a drawing, such drawing may be *pinned* down on the drawing board without reference to the T square; or it may be that a drawing is already attached to a board, and the T-square applied to it may not coincide with the horizontal lines—in either of these cases, by the adoption of the attachment, a correct adjustment may be immediately obtained. Unless there is much use in an office for such an appliance as is described, one attachment may be made to do duty for several T-squares, provided each is fitted with plug nuts. This attachment has been devised by Mr. James P. Maginnis, of 9, Carteret-street, Westminster, S.W.

G.W.R. Mechanics' Institution, New Swindon.—A special meeting of the Junior Engineering Society in connection with the recent excursion to London on September 16 was held in the lecture hall of the institution on Friday last. Mr. A. E. Leader presided over a moderate attendance. Mr. H. G. Cotsworth read a very good paper on the City and South London Electric Railway, the first place visited by the members on the above date; and of the other—viz., the G.W.R. Electric Lighting Works at Paddington—the manager, Mr. G. B. Clifton, responding to the invitation of the meeting, gave an interesting description later on in the evening. Mr. Cotsworth's paper opened with an account of the restrictions and obstacles the engineers had to contend with in the construction of the railway, diagrams showing the Greathead system of tunnelling were submitted, with a description of the operations, supplemented by the details of the design of the tunnel and an enumeration of its most interesting features The working of the system, safety appliances, and brakes employed, and the hydraulic lifts all came in for attention, and the paper concluded with full details, illustrated by sketches of the electric locomotives. Mr. Clifton, assisted by sketches, very clearly defined the arrangement of the plant at Paddington, and commented on the reasons for and advantages of the system. Full and instructive particulars of the construction of the dynamos were advanced, and also of the running and general output of the machinery. The chairman, with Messrs. Clifton, Cotsworth, Tincknell, T. C. Davidson, Seymour, and Shepherd, joined in the discussion, in which views were freely exchanged on the haulage, general working, and locomotives on the electric railway, and also on the two systems of electric current transmission and the construction and lubrication of dynamos.

French Cable in the Pacific.—"The laying of the French cable between Queensland and New Caledonia is of itself evidence of enterprise which at a dull time is satisfactory. Indeed, we might well add," says the *Melbourne Argus*, "that Victoria would have gladly borne a share of any subsidy required to establish communication with the French settlement (supposing there were no ulterior object) on the well-understood principle that what is to the advantage of one colony is to the advantage of all. But in regard to this particular cable there are well-known circumstances that give an unpleasant tone to the announcement that it is to be laid in a few days. It is intended to be a link in a great Pacific cable to connect Australia with America, and if its projectors succeed in their scheme it will be almost wholly under French influence. Though primarily the contract with Queensland and New South Wales is for a cable to New Caledonia, the avowed object (and to this the two colonies have virtually committed Australasia) is to extend it to Canada. In other words, what is tantamount to an Australasian bargain has been made by two members of the group without consultation with the others, and the Governments of Victoria, South Australia, Tasmania, and New Zealand have been powerless to interfere. It has not, of course, been absolutely decided to continue the cable from Noumea to

Vancouver; but once the first section is laid the French company will command the situation. There is not likely to be room for two Pacific cables for a generation or more, and if the French line is laid, as appears probable, it will have a monopoly of business. In view of the desirableness, from the national standpoint, of having the connection between Australia and Canada wholly under British influence, the prospect is certainly displeasing. It is the more so because of the feeling that Queensland and New South Wales have to some extent jockeyed the other colonies, Queensland having a special object in doing so, because her governments have been consistently unfriendly to the existing cable service. They have assumed a federal responsibility without federal sanction, and their action is calculated to greatly strengthen French interests in the Pacific. If ever need were shown for the federation of the colonies, this is an instance. As it is, the only course open for the dissenting colonies is to notify that they are not bound by any promises made by the Queensland and New South Wales Governments to support the extension of the cable beyond New Caledonia. Knowledge of their dissent may have a restraining effect upon the projectors of the line." The *St. James's Gazette* in a recent issue reprinted the above Australian opinion on the Pacific cable. Since then the cable has been laid.

Apparatus for Measuring Insulation. — In the foreign abstracts of the Institution of Civil Engineers, an apparatus for measuring insulation is described as given by M. H. Armagnat in *L'Industrie Electrique*. In 1881 Mr. Carpentier devised an instrument consisting of two concentric coils fixed with their planes at right angles to one another, and embracing a movable system of magnets or soft iron. The coils were connected in parallel, and on passing current through them the resultant field caused the movable system to take up a position proportional to the ratio of the currents in the coils, and therefore of their resistance. The idea was not novel, having been published by Maxwell, and Mr. Carpentier abandoned it. With the development of electric lighting, a demand has arisen for an instrument that will bear rough usage and indicate resistances in a simple manner with a fair amount of accuracy. The instrument just described is very suitable and has been revived by the inventor. In its original form it was very liable to be affected by the earth's field, and in order to render this negligible the field due to the coils must be very strong. In the improved instrument there is combined the principle of the Deprez-d'Arsonval galvanometer; instead of fixed concentric coils, two rectangular frames are mounted at right angles to one another, and are carried on pivots working in jewelled holes; they move in a very intense field set up by horseshoe magnets, the circuit of which is completed by pole-pieces of fixed soft-iron cylinders. The current is led into the coils by long spirals of very thin silver wire, the disturbing effect of which on the deflection is negligible at a pressure 20 per cent. less than that employed. One coil is connected to the source of current and the other in series with the resistance to be measured, the circuit so formed being placed as a shunt to the first coil. The resultant field is a minimum when one coil acts alone—*i.e.*, when the resistance to be measured is infinite—and a maximum when the maximum current flows through both—that is, when the resistance is zero. The disturbing effect of the leading-in wires is, of course, of greatest relative importance when the field is at a minimum, and it is arranged, therefore, that they shall tend to direct the index towards infinity. A switch is provided which alters the sensibility by shunting the coils, the instrument reading up to 50,000 ohms, 500,000 ohms, or five megohms, according to the position of the switch. A magneto-electric generator, giving 120 volts at 100 revolutions of the handle per minute, is provided. The author points out the necessity for the current being continuous, in order to avoid error when measuring the insulation of cables having appreciable capacity. When the speed is such that 100 volts is attained, variations in speed do not affect the indications of the instrument.

The Hydrograph.—The remarkable property possessed by water for conducting sound is well known, but we are not aware that any successful attempt has hitherto been made to turn that property to account for signalling purposes. Its utilisation in that direction, however, seems to have been effected in a practical manner by Captain Neale, who has devised a system by means of which signals can be given, messages exchanged, and conversation held between ships on the sea or on rivers, whether moving or stationary, or between ships or lighthouses and harbours, forts, or piers on the shore, or *vice versâ*. Communication, moreover, is effected without any connection whatever between the two objects except the body of water in which the ships float or the lighthouse stands, the water being the sole medium through which the message is transmitted. The system depends for its action upon harmonics, and its principle will be understood by a reference to the well-known fact that upon a musical note in a given key being sounded an object capable of emitting sound in the same key will, under certain conditions, sympathetically respond by emitting a sound similar to that which awakened its vibrations. It is, of course, a primary condition that the two objects shall be normally tuned in unison. Working upon this fixed principle, and utilising the high conductivity of water for the transmission of sound, Captain Neale has constructed a signalling apparatus, which consists of a transmitting and receiving instrument, which, when in operation, are in no way connected with each other except through the medium of water. The apparatus by which a correspondent of the *Times* recently saw the system exemplified is mounted on two punts, the transmitter on one and the receiver on the other. The transmitter consists of a bell about 16in. diameter attached to the lower end of a framing which is fixed to the side of the punt, the bell being submerged about 6ft. At the upper end of the framing is a crank handle, which is worked from the punt and actuates a double-beat hammer which strikes and sounds the bell. The Morse code is employed, and signalling is at present carried on by hand, but electricity is intended to be used. The operator gives the handle a quarter turn for the dots of the code, and a whole revolution for the dashes. The receiver, which is on the second punt, consists of a pair of metallic drums, about 10in. diameter, open at one end and fixed, mouth to mouth, upon a piece of board which is sandwiched in between them. These drums are suspended in the water, and are connected up with a small battery, and through it with a tape recording instrument. As at present arranged, the operator has an acoustic apparatus connected with the drums, by means of which he hears the sounds from the bell as they are received by the drums, and, by a manual arrangement, he records each sound on the tape. Upon the occasion of the inspection, the two punts were moored in the Thames at Kingston, about two-thirds of a mile apart, and signalling was successfully carried on from the one to the other. Messages were correctly transmitted and recorded, although naturally somewhat slowly, owing to the apparatus being at present worked by hand. The trial, however, is said to have demonstrated the practical character of the invention and the correctness of the principles upon which it is based.

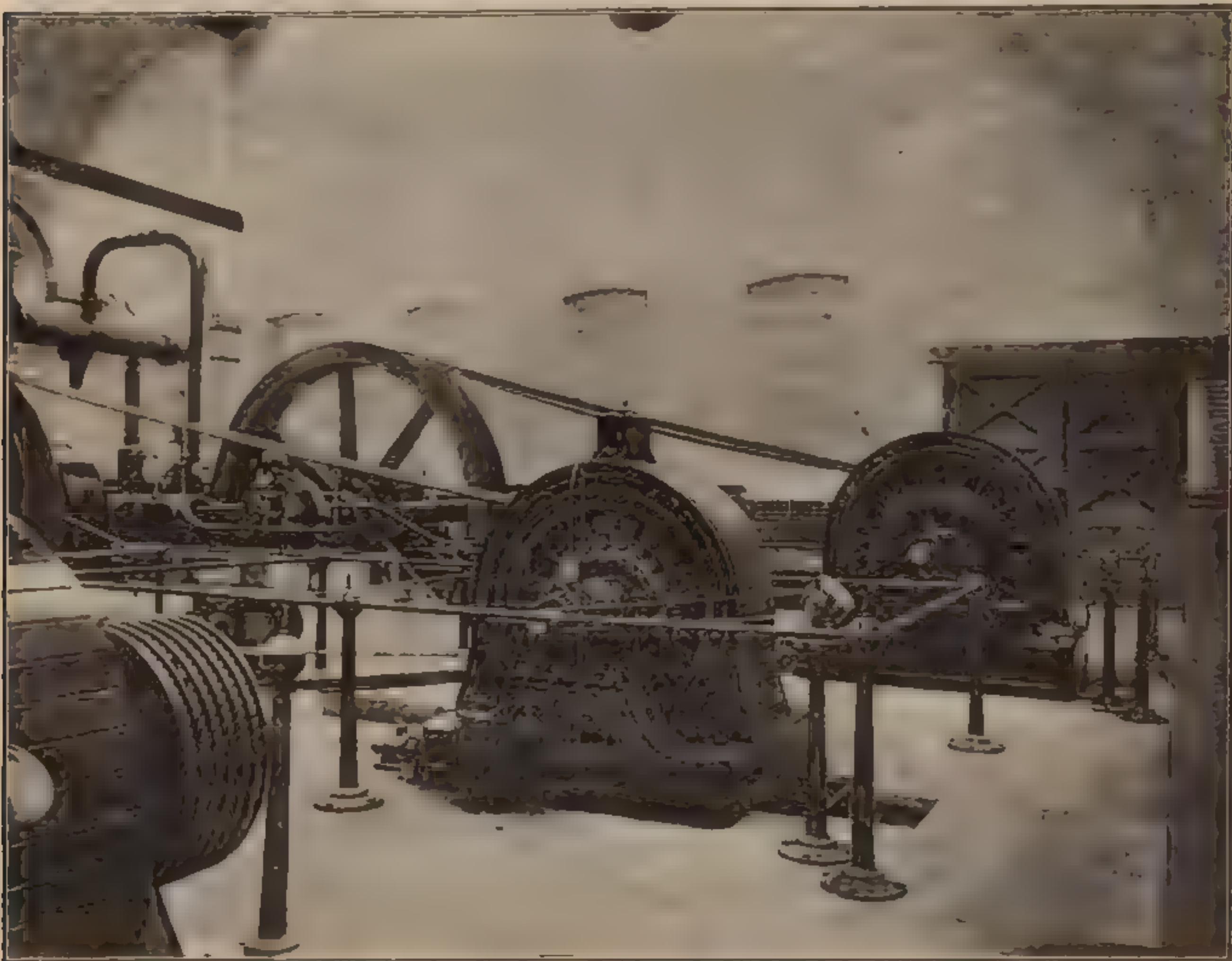
BLACKPOOL.

Last week was a busy week in matters electrical, seeing that two central stations controlled by municipalities were formally opened. The Derby station we referred to in our last issue, the opening of that station being on the Tuesday, while the opening of the Blackpool station, to which we shall now refer at some length, was held on Friday. Blackpool, as many of our readers well know, prides itself upon being the Brighton of the North-West. Its desire is to attract visitors, and no stone is left unturned to accomplish this object. A magnificent sea front, with its three piers, its sands, and miles of promenade, are the main features of attraction, but other places have as good sand and sea, which fail to render them as popular as Blackpool. A popular seaside town must have other than natural attractions, and Blackpool recognises this; hence its piers with their pavilions, its winter gardens, its Eiffel tower, not to speak of theatres and other places of amusement. Private enterprise may do much in providing attractions, as it may in establishing good hotels and boarding-houses, but the authorities are interested in obtaining the best sanitary arrangements, the best water, the best roads and streets, and the best light. Blackpool may fairly feel satisfied with itself in these directions. Our interest is more in matters relating to traction and lighting, in both of which Blackpool is progressive than in the other matters mentioned. In 1878 some little excitement was given to electrical circles by the success of the Jablochkoff candle, and it was not long after this that Blackpool thought the lighting of the promenade by electricity might prove an attraction. The late Sir W. Siemens—or perhaps we ought to say the firm of Siemens Bros.—undertook the work, and erected some half-dozen arc lamps of 6,000 c.p. nominal upon masts 60ft. high along the parade. Each lamp was energised by a separate machine, and for something like 13 years these dynamos and lamps have been running, being to-day seemingly as good as ever. Thirteen years in a progressive age is a long period in the history of a progressive town. The period has seen the development of the incandescent lamp, not to speak of the improvements in dynamos and alternators, and Blackpool came to the conclusion a year or two ago that what was good at the end of the seventies might be somewhat old-fashioned in the nineties, so a provisional order was obtained in 1890. For 18 months the matter was left in abeyance; then came a period of activity. Sanction was obtained for borrowing money for a central station and lighting work, plans were approved, and Mr. Robert Hammond became consulting engineer and contractor for the generating and distributing plant. The buildings are from designs submitted by Mr. Hammond and plans prepared by Mr. J. Wolstenholme, the borough surveyor, and have been carried out by Messrs. Whitehead, Mr. Hartley, Messrs. Kay and Son, and Messrs. Walmsley. The site of the station is adjoining the sidings of the Lancashire and Yorkshire Railway, and near the centre of the area of supply, giving two advantages in the easy and economical carriage of coal and reducing the initial cost of mains. We are quite sure that many of the engineers who were present at the opening ceremony envied the possession of so commodious a set of buildings. The engine-room is 125ft. long by 54ft. wide. Across this room is a travelling crane, by Carrick and Ritchie, of Edinburgh, to lift 10 tons. A plan of the engines and dynamos contained herein is given, there being already in work one 200-h.p. engine driving by

Engine and Dynamo Room—Blackpool

ropes one 100-kilowatt Lowrie-Hall alternator, two 100-h.p. engines each driving a 50-kilowatt alternator, and three 60-h.p. engines each driving a Brush dynamo for the arc lighting circuits. Room is left for other plant which is to be put in for driving the electric trams; when this is done the old tramway station will be closed. At present the plant is capable of supplying 12,500 8-c.p. incandescents and 165 arc lamps, each 2,000 c.p. nominal. Unless our memory is at fault, we understand that the whole of the arc lighting plant is fully loaded, while from one-fourth to one-third of the incandescent plant is required. The following details of the machinery have been supplied to us by the contractor.

Engines.—The type of engine selected is that known as the horizontal, coupled, compound, non-condensing, those erected in these works having been manufactured by Messrs. John Fowler and Co., Leeds, the size adopted being considered a suitable unit to work in sections, having where the strength of the plant has been subordinated to economy. The strength of the crankshaft and the length and surface of the bearings are also notable features, as are also the size and weight of the flywheel. Great care has been exercised in providing for the lubricating arrangements; the supply of oil being regulated, caught after first use, conveyed to a suitable reservoir, filtered, and used again, thus greatly economising this too often fruitful source of waste. The engines are securely railed in, and between the foundation pillars and over the pipe trenches chequered iron foot-plates are placed, giving the whole a very neat appearance. The flywheels are all grooved for rope-driving, this being found the most easy and economical method of working. The ropes on the 200 h.p. engine are 1½in. diameter, and are eight in number. Details of the two 100 h.p. engines are as follows: Speed, 120 revolutions; high-pressure cylinder, 11in. diameter; low-pressure cylinder, 18in diameter; stroke, 20in.; flywheels, 10ft.



Lowrie Hall Alternators Blackpool

regard to the varying load. The speed of the largest engine is 90 revolutions per minute, and the ordinary working load 200 i.h.p., at a steam pressure of 125lb. per square inch, but the engine is capable, by increasing the steam pressure to 140lb., of working up to 250 i.h.p. as a maximum load. This is one of the many central-station requirements already alluded to—viz., the existence of a good margin which may be safely called upon whenever it may be necessary to provide for an emergency, a point often overlooked in electricity works design. The chief dimensions of the 200-i.h.p. engine are: High-pressure cylinder, 15in. diameter; low-pressure cylinder, 24in. diameter; stroke, 30in. The slide bars and the cross-head shoes have extra large wearing surfaces arranged on each side of the connecting-rod, and are made in such a way that easy adjustment is possible without any complications. Another point in these engines worthy of note is the massive character of the bed-plate, a characteristic not found diameter, grooved for six 1½in. ropes. The details of the three smaller engines are as follows: Speed, 150 revolutions; high-pressure cylinder, 9in. diameter; low-pressure cylinder, 14in. diameter; stroke, 16in.; flywheel, 6ft. diameter, grooved for six 1½in. ropes.

Alternators and Arc Dynamos.—(*a*) One 100 unit alternator of the Lowrie Parker type. The electrical working pressure is 2,000 volts, at a speed of 375 revolutions per minute. (*b*) One 50 unit alternator of precisely the same build as the above, to give 2,000 volts at a speed of 500 revolutions per minute. These two machines were made by the Electric Construction Company, Limited, Wolverhampton. (*c*) One 50 unit multipolar alternating-current dynamo of the Hall Hammond type, having the most recent improvements, and manufactured by Messrs. John Fowler and Co., Leeds. [We understand that this is the first of these improved alternators in use.] All these machines have been specially constructed to

synchronise or run in parallel with each other at all loads. The field magnet and armature conductors do not carry more than 2,000 amperes per square inch of section, thus allowing a good working margin. Uniform with all the rest of the work, and in order to provide for the perfectly safe working of the plant at every point, the terminals to which the high-tension mains are connected are securely boxed in by polished wood lagging, so that they cannot be touched except by the proper official. The exciters for these alternators are driven by ropes from a grooved pulley on the alternator shaft, and are each of ample size to generate current sufficient to easily excite the fields of the corresponding alternator at full load. The bearings are all of good length and have large surface, and are, moreover, each provided with a water-jacket and water fittings for use in emergencies. The arc lighting dynamos, of which there are three, are capable of lighting 55 arc lamps, taking 10 amperes, and each of 2,000 nominal candle-power when driven at a speed of 800 revolutions per minute. They are of the Brush type, and are fitted with the most recent improvements for adjusting the collecting brushes, and for working at a pressure of 3,000 volts with a minimum amount of sparking at the commutator. All the alternators and arc dynamos are provided with slide rails, by which they can be moved to regulate the tension on the ropes.

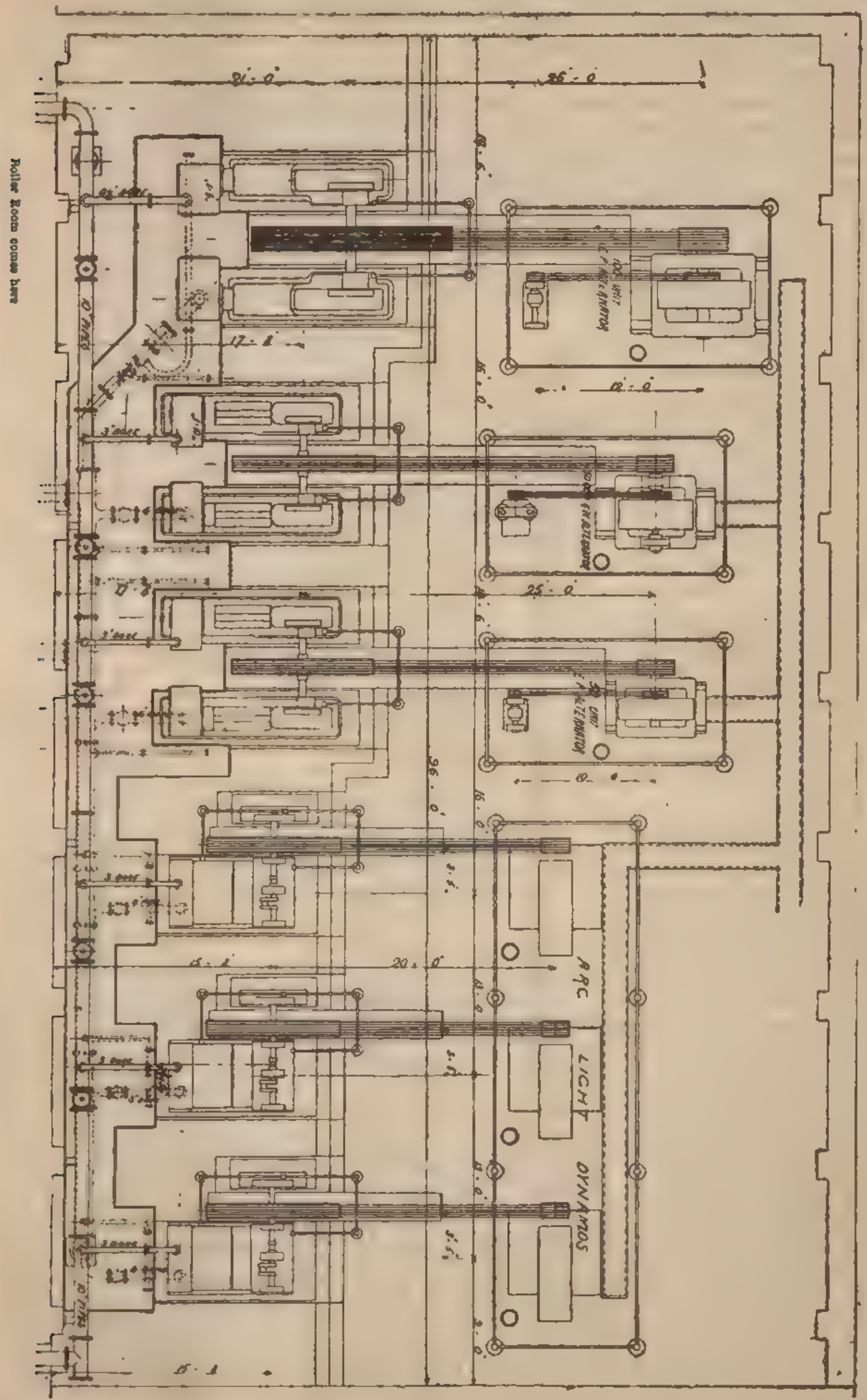
The boiler-house is 124ft. long by 54ft. wide, and in it are placed three Lancashire boilers, made by Messrs. Galloway, Limited, Manchester, each 28ft. long by 7ft. diameter, constructed for a working pressure of 140lb. per square inch. A plan of part of the boiler-house with the boilers is given herewith. They are fitted with Proctor's mechanical stokers. These are worked by means of a small engine, driving by a belt on to a line of shafting, and from thence on to the actual stoker's shafts by ropes in the usual way. Meldrum's special appliances for producing a forced draught, so as to assist the combustion of coal at times of heavy demand, are fixed on two of the boilers. The third is fitted with Proctor's moving fire-bars. Two feed-water heaters are also provided.

A very careful but simple arrangement of pipes, rendered necessary by so many auxiliary parts of the plant, including all the requisite pipes to and from the engines, feed-water heaters, pumps, tanks, etc., has been neatly worked out. An auxiliary steam-pipe is provided for supplying the pumps and stoker engine, independent of the main steam-pipe. The donkey pumps for feeding the boilers are of the duplex ram type, each of sufficient capacity to feed two boilers when working at their full power. The main steam-pipes are connected up in the form of a ring, to which both boiler and engine branches are connected, thus providing two ways by which the engines can be supplied with steam. These pipes are provided with a suitable number of stop valves placed between engine and boiler. The pipe forming the main steam-ring is 10in. diameter, and is carried on brackets fixed to the wall of engine-house. The branch pipes to the engines are of wrought iron with wrought-iron flanges. The whole of the steam-pipes were tested by hydraulic pressure to 300lb. per square inch after erection in the works. The exhaust-pipes lead off from under the low-pressure cylinders, and a stop valve is provided to each engine exhaust to shut it off from the main exhaust-pipe. Valves are arranged so that the whole or part of the exhaust steam can be turned through the heater or direct into the atmosphere through the roof of the boiler-house.

Distribution.—The distribution of electricity is effected by means of stranded copper cables, insulated with vulcanised indiarubber and laid in a specially designed system of pipes combined with service and junction boxes. Each junction-box has a loose cover, held in position by a wrought-iron clamp. The culvert connection from the box to the consumer is made by a wrought-iron pipe. The surface boxes are in all cases placed at the corners of the roads, and in the case of a long straight run they are placed at distances of 80 to 100 yards apart. The surface boxes are made in two parts, the bottom part being permanent and the upper part with the cover being adjustable, so as to allow its surface to be raised or lowered as the road level may vary, the lid being filled in with wood, macadam, or pavement, according to the construction of the road. From the surface boxes the cable can be drawn in or out as required. Where passing round corners the cable is placed on a revolving drum, which entirely prevents the possibility of abrasion. The jointing of branch cables for consumers' premises is done by cutting away part of the insulation of the main cable, which consists of indiarubber in the junction or surface boxes, and soldering the copper conductor to the conductor of the branch cable. The joint is then lapped over with rubber to the full thickness of the original insulation, and vulcanised on the spot, and the cable well taped and mechanically protected. The farthest distance at which current is at present being supplied is about two miles from the works, the length of cables laid being over 14 miles. At suitable points throughout this system the manholes break up the cables into sections, and afford easy means of stopping the mains for tests and inspection when desired.

The lamp pillars, which are of cast iron, are 25ft. high, having the arms of the borough upon a panel. The columns are fluted, and have an octagonal base which is highly ornamented. The upper part of the pillar is of uncommon description, the lamp being contained under a canopy with ornamental carriers on each side. The design as a whole, including the carrier and dome, is very much after what is to be seen in Paris, and the instructions given to the makers (Messrs. George Smith and Co., of the Sun Foundry, Glasgow, and 199, Upper Thames-street, E.C.) by the Blackpool Corporation were that the Parisian pillars should be worked to as nearly as possible. There is a large root to the pillar, 3ft. 6in. to 4ft. long, the object being to provide against the great strains met with through the severe storms which prevail locally. The pillars were greatly admired, and many people would concede the claims of the makers that they are almost, if not quite, the most handsome in existence.

The arc lamps are of the Brockie-Pell type, manufactured by Messrs. Johnson and Phillips. These lamps are so well known and have obtained so great a popularity that further description here is needless. The spectacle of some hundred or more of these lamps illuminating the whole length of the promenade, a length of between two and three miles, was magnificent. The lamps are 2,000 c.p. nominal, and placed about 50 yards apart. One minute on Friday night we had darkness, the next the whole of the lamps were flashing out their radiance, and making the Blackpool front the best-illuminated promenade in—yes, we thoroughly believe the best in the whole world. There may be a few shorter lengths with a greater concentration of light, but here, all along, the light is ample; and if Blackpool desired, she has attained her desire of the best-lighted promenade that can be seen. As an additional attraction to inaugurate the opening of the station, the authorities had arranged a kind of gala time, during the evenings of which not only was the promenade lighted as we have described, but the nearly-completed Eiffel tower was festooned with incandescent lamps lent by the Manchester Edison-Swan Company, and crowned with a projector loaned by Messrs. Clark Chapman, of Gateshead-on-Tyne. This illumination was fully appreciated, and the outline of incandescents with the flashing of the projector made a pretty sight. Before referring to the opening proceedings a word may be given as to the prospects of the station. That they are very favourable will already have been gathered, but we think that not only are they favourable, but that success is certain. Enquiring, as journalists are apt to do, about the amusements of the town, we were directed to the Opera. Of course all electrical engineers tend towards good singing—witness the success of our Electro-Harmonic, under the able guidance of Mr. Gatehouse and his colleagues. But this is a digression. The Opera House was found to be part and parcel of the Winter Gardens, a place of renown and of pleasure, under the management of that most energetic of entertainers, Mr. William Holland. The demand of Mr. Holland for lighting is fairly large for a small town. He takes current for 40 arc lamps, and for about 1,000 incandescents, each of 16 c.p. to 50 c.p. We cannot fully describe this installation. It was carried out by the Manchester Edison-Swan Company. So far as the Opera House is concerned, however, the following description has been furnished.



Plan of Engine and Dynamo Room—Blackpool.

The auditorium is lighted by means of eight particularly chaste and unobtrusive crystal pendants close to the roof, and the decorative effect of these is enhanced by nine handsome two light ormolu and crystal brackets arranged round

the fronts of the dress circle and gallery balconies. These fittings, while having been specially designed for their particular positions, are of one general design throughout, and are really charming combinations of highly artistic brass-work and prismatic crystals, the effect of which is exceedingly pleasing.

The whole of the lamps in the auditorium are controlled by a simple arrangement of switches on the prompt side of the stage. On the stage itself only the foot and proscenium lights have yet been arranged, though for several weeks an electrolier has been in use in various scenes. It is intended, however, to use the electric light almost entirely. Floats, battens, and other stage appliances are being arranged with various coloured lamps and the necessary switches to cut off or vary the light as required—the whole will be carried out on the latest principle and in the most careful and substantial manner—so that Mr. Holland and his staff will be able to produce scenic effects such as have not been hitherto seen in Blackpool.

The whole of the installation has been laid down with the object of safety, durability, and efficiency. Twenty pairs of mains run back to a distributing room in the basement. Each main has no possible connection with another, and is controlled by patent switches and cut-outs manufactured by the contractors. These mains run to as many distributing-boards, placed conveniently, and arranged to control a definite number of lights, and by no combination of accidents can all the lamps in one department be put out at the same time. Every wire is protected by a fuse, and perfectly controlled by a switch, so that the public can have every confidence in the steadiness and continuity of the light.

It may be mentioned that in carrying out the installation about 12 miles of wires and cables have been laid down.

The work has been carried out by the contractors, the Manchester Edison-Swan Company, in a manner consistent with their reputation for excellence under the supervision of their resident electrician, Mr J B Burroughs, and an excellent staff. The Winter Gardens Company has also appointed its own resident electrician, Mr. A. Fairley.

Arc Lamp post at Blackpool.

THE INAUGURAL CEREMONY.

The official programme of Friday's proceedings was as follows, so far as electrical matters were concerned:

At 4.15 p.m., guests and other gentlemen to assemble at the Corporation electricity works—entrance from Coop-street and West Caroline street.

At 4.30 p.m., the Mayor (Alderman Cardwell) and the Chairman of the Electric Lighting and Tramways Committee (Councillor Pearson) to receive Lord Kelvin at the electricity works.

At 4.40 p.m., the chairman to introduce Lord Kelvin, after which the engines will be started at a given signal from his lordship. Lord Kelvin and other gentlemen to deliver short addresses. The Mayor to propose a vote of thanks to Lord Kelvin, and the ex-Mayor (Alderman Buckley, J.P.) to second the same. Inspection of the electric lighting station by the visitors.

At 5.45 p.m., the company to proceed to a platform on the Marine Promenade, near the north side of the Central Pier, where,

At 6 p.m., Lord Kelvin will switch on the new arc light system, to extend the whole length of the promenade, and comprise 101 lamps of 2,000 c.p. each.

At 7 p.m., dinner to invited guests at the Clifton Arms Hotel, Blackpool.

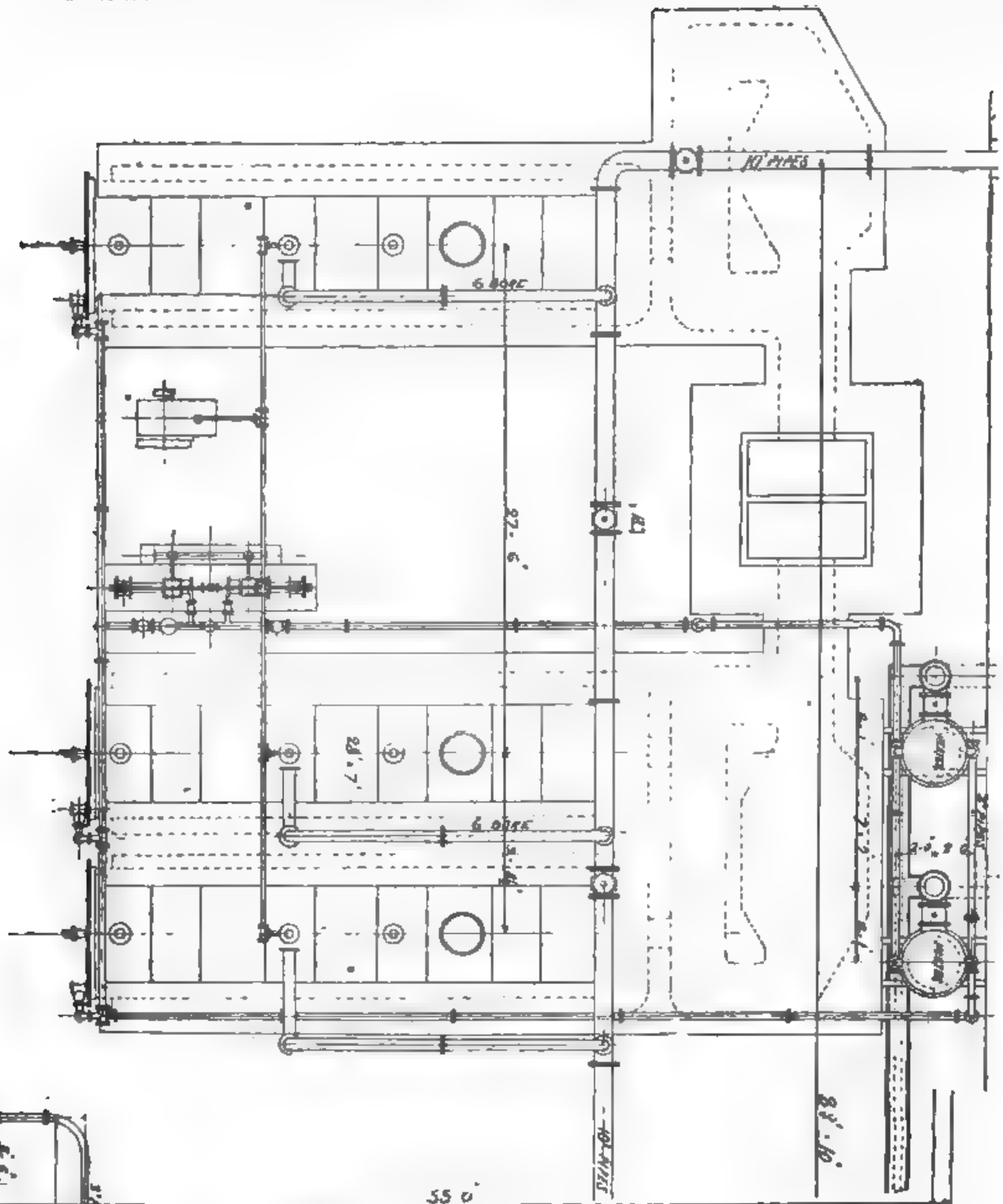
From 7 to 10 p.m., inspection of the electricity works by the public—entrance from Coop-street and West Caroline street.

Brilliant illumination of the whole length of the promenade.

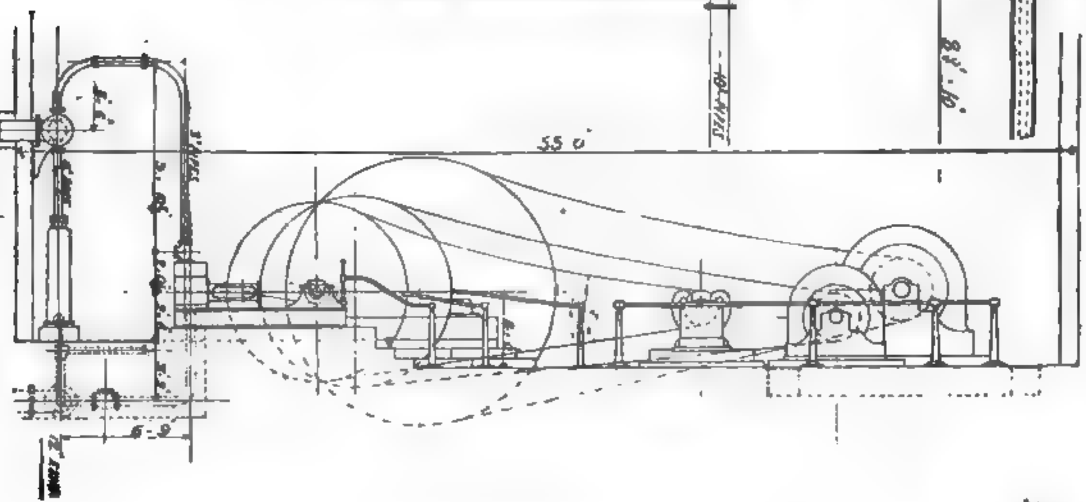
The Blackpool Eiffel Tower outlined against the sky by means of thousands of electric lights, and crowned with clusters of arc lamps surmounted by a powerful search light, visible for a distance of 30 miles.

We can but briefly refer to the ceremony. From first to last everything was successful, and Mr. Hesketh is to be congratulated upon the success of his indefatigable labours. Words of praise are feeble to express the energy, the resourcefulness, and the capacity to fill every man around him with enthusiasm that Mr. Hesketh displayed, and that in the teeth of illness that would have incapacitated a less determined man. The contractors and the authorities have much to thank their able electrical engineer for, and we are sure they will be quite willing to acknowledge his great services. Assume the company assembled, the Mayor in the chair at the engine-room, Lord Kelvin on his right, a galaxy of notables all around. The Town Clerk tells of absentees, the Chairman of the Lighting Committee gives an admirable *résumé* of the history of Blackpool's work as regards electrical matters, and then the guest of the day—Lord Kelvin—rises to bid the engines start on their career—one which we emphatically hope will be long and successful. It has been our pleasure—not perhaps wholly unprofitable—to have listened at the feet of the electrical Gamaliel many a time, and yet we have failed to understand the many-sided perfectness of his character. He shines as much before a popular audience when discoursing on things of local interest as he does before a scientific audience when expounding scientific truths that are understandable only by the selected few. Lord Kelvin touched lightly upon the position Blackpool holds as regards electric lighting; how it was among the very first to adopt the new illuminant, how it is among the first to have a central station belonging to the municipality. He was clear and decisive in his rendering of the duties of municipalities. Should they become purveyors of water? Yes. Of gas? Yes. Of electricity? Yes. Of letters, telegrams, telephones? No. The municipality should be responsible for localisms, not generalisms. These views were highly appreciated and applauded. Then came the crucial moment when he asked Mr. Hesketh to start the machinery, and, lo! with one accord the massive flywheels revolved, as did the various armatures, and the installation, without a hitch, without a moment's delay, was publicly opened. After a saunter round the works the visitors made their way to a temporary platform on the promenade, from which the arc lights north and south were switched on, and, as we have previously said, the whole sea-front was flooded with light. As for the dinner, admirably served at the Clifton Arms Hotel, and the after-dinner speeches, all excellent, but of local interest rather than of national—these formed the closing scenes of an inaugural ceremony of the most successful kind.

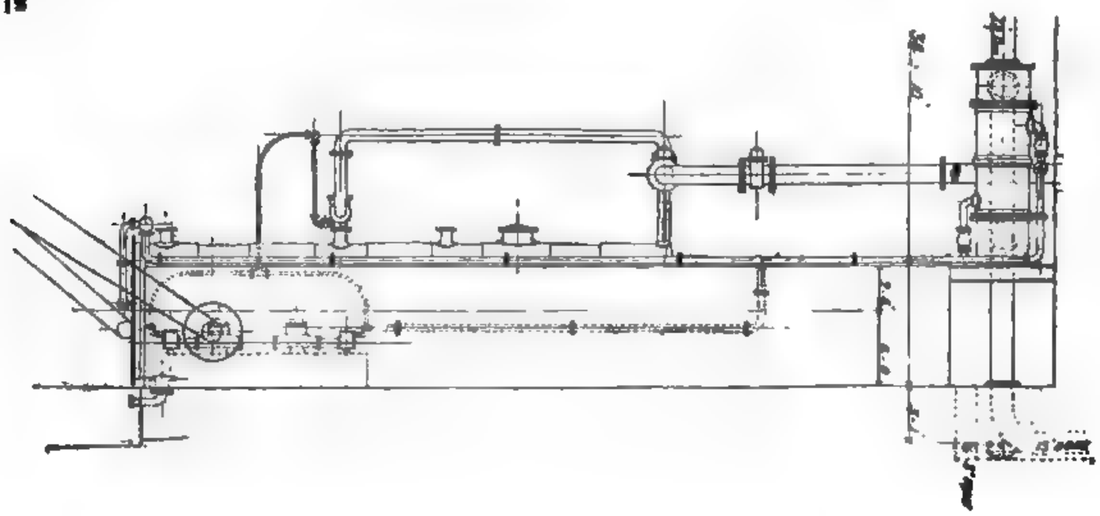
The Siam Electric Tramway.—This tramway, to which reference has been made in previous issues, was set in operation in February last. It is a single line 3¾ miles long, suitable loops being provided at intervals. It commences at the terminus of the horse-car line near the centre of the city, and continues to the suburbs of Bang-Rak, along the new road to Bang-Mai, and then through fruit gardens to Bang ko-lem. Here a swift current sets in in the river, and people coming from the surrounding country in boats alight and continue their way to the city by the tramcars. The trolley wire is hard-drawn copper with bracket suspension, as the line is at the side of the street. Teak-wood poles are used, as they are the only kind secure from the ravages of white ants. There are six cars, and Short single-reduction 20-h.p. motors are used, one to a car, these being controlled in the usual manner by rheostat and contact-board worked from either end of the car. The generating station is at the city terminus of the line, where it connects with the horse tramway continuing through the city to the palace. There are two 80-h.p. tubular boilers, and the fuel used is sawdust. The engine-room contains two high speed engines, driving two Short 40,000 watt generators. The entire plant has given excellent results. The manager of the company is so satisfied with the performance of the system that he has placed orders for four more cars.



Plan of Boilers



Section through Engine Room.



Section through Boiler Room.

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CONTENTS.

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SPEAK OR BE SILENT—WHICH?

It is often extremely difficult to decide whether to speak or remain silent. The old adage inclines to the latter, but a too servile following of the best instructions is apt to lead astray. We may be wrong, but the time seems opportune to discuss certain questions relating to the work and responsibilities of municipal electrical engineers. Central stations are rapidly coming into action. These central stations have been designed by consulting engineers, and are in due course handed over to the resident engineer. A close watch will be kept upon the results obtained, and the resident engineer will be held responsible for success or failure. This brings us to the question, Is it possible at any time to legitimately criticise in an adverse manner any design for a central station? and, in reply, we have come to the conclusion that under no ordinary circumstances can such criticism be justified. That may seem a queer conclusion—perhaps may be taken to imply a certain weakness; but let us examine a little more closely. Given a central station erected and opened, damning with faint praise will not lead to an alteration of the fact. Such as it is, the money having been spent, it must be made the best of. Outside critics may see that the design is faulty; that in actual results this faulty design will bear hardly against them, and in comparison with other better-designed stations must take a back seat. In the dim and distant future, as the resident engineer makes up his report, and tabulates his figures so that they may be compared with other returns, he will find his committee looking askance because the figures he gives are not so favourable as those given by this or that other station. The engineer whose results lead to the worst figures may in reality be an abler man than he whose results give the better figures, but is severely handicapped by the tools which he has to use. When we find that the cost of producing a Board of Trade unit is little more than three halfpence in some places, and as much as threepence, fourpence, and even sixpence in others, this great difference cannot be attributed solely to bad management or cost of materials, but faulty design must come in somewhere. How heartbreaking is the position of the resident engineer whose results are bad compared with those of some colleague whose materials cost about the same. We are pointing these matters out because many municipalities are going on the wrong tack. Instead of carefully examining what men have done, they throw open their work to a kind of indiscriminate competition, which not infrequently must lead to weakness of design. Human nature is human nature, and the competitors desirous of getting the work can hardly be so careful as if they were employed directly and without these competitive trammels. Therefore, while some municipalities will have themselves only to blame, they will forget their own action and impute blame to the electrical engineer who has the unfortunate task of putting balance-sheets before them. The difference of, say, one penny per unit cost for an output of a million units will probably be enough to pay two and a half per

cent. upon the total capital outlay of the producing station. It will be contended that the figures at our disposal are as yet the results of immature working, and that is so, though we fail to see how the cost per unit in a fully-developed station should increase above the cost in an undeveloped station. In other words, if a station can produce at twopence per unit when working at half or three parts its capacity, it certainly should be able to produce at twopence, or under, when working at its full capacity. The variation of figures now obtainable may be largely due to the undeveloped state of the stations, but we have the minimum cost as a guide, and the conditions under which that minimum cost is obtained. The future comfort, then, of municipal electrical engineers will depend largely upon the machinery and its arrangement as handed over to them. Economy of maintenance should play a larger part in the creation of a design than economy of initial expenditure. These are some of the views which lead to the conclusion that the proper time to criticise a design is, to use an Irishism, before it is commenced, and the improper time is ever after it is finished, that is, of course, if the criticism is to do any good. If it is only to be able to say "I told you so," why any time after completion will do. The municipal electrical engineer is going to be the ultimate arbiter as to the best systems to follow, and the sooner he realises this the better, and then we shall the sooner have him exercising a collective influence.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

CARDIFF ELECTRIC LIGHTING.

SIR,—We beg to hand you copy of a letter which we have addressed to the borough engineer of Cardiff, and which we think of sufficient general interest to bring under your notice.—Yours, etc.,

S. LAMBERT, Secretary,
Callender's Bitumen, Telegraph, and Waterproof Company, Limited.

101, Leadenhall-street, E.C., October 18, 1893.

"101, Leadenhall-street, E.C., 16th October, 1893.

"Dear Sir,—We beg to confirm the telegram sent you to-day as follows:

"'Notice of your Corporation requiring tenders for cables only published in Friday's electrical papers. Tenders required to be sent in to-day. Time manifestly too short. Will you grant extension? Please telegraph reply.'

"and have received your reply:

"'Extension of time for receipt of tenders impossible.'

"Under these circumstances, we desire to lodge a formal protest against the method of inviting tenders which you have adopted, and the totally insufficient time which has been given to independent contractors to make their calculations and to prepare the necessary offers.

"We have made enquiries, and find that your Corporation has not advertised in any of the papers devoted to electric lighting, the notice to which reference is made in our telegram to you being taken from the press outside the electric industry.

"We call your attention to the fact that this is the first contract for electric cables 'advertised' by a corporation which has not been fully announced in the trade journals.

"The method you have adopted in inviting tenders precludes open tendering by independent manufacturers.

"If your Corporation had decided to invite certain makers to a private competition we would have had nothing to say, but we distinctly protest against action such as has been adopted in the case of Cardiff being considered as a public invitation to tender.

"We reserve to ourselves the right to make this letter public.—Yours faithfully,

"Callender's Bitumen, Telegraph, and Waterproof
"Company, Limited,
"T. O. CALLENDER, Manager.

"W. Harpur, Esq., borough engineer,
"Town Hall, Cardiff."

THE TESTING OF INSULATED WIRES.

A series of tests of insulated wires is being made at the Chicago Exhibition by a sub-committee, consisting of Profs. Owens, O'Dea, and Jackson.

The wires entered for the test are the okonite, kerite simplex, Grimshaw, and those of the India Rubber Comb Company, Washburn and Moen Manufacturing Company, and the Western Electric Company. We learn from the *Electrical Engineer* of New York that the wires will be subjected to the usual tests for resistance, insulation, and electrostatic capacity. In addition to this, however, they will undergo a breakdown test to determine at what potential the insulating material suffers puncture from the applied E.M.F. The method employed for this test is almost identical with that which has for some time past been in use at the works of the Westinghouse Electric and Manufacturing Company. Indeed, the apparatus employed by the judges has been placed at their disposal by the Westinghouse Company for this purpose. The current required to break down the wires is obtained primarily from a 100-volt alternating circuit. This is first passed through a safety switch, and then through a special double-fuse block. In arrangements of this nature it is, of course, necessary to prevent the high tension from reaching ground or the primary, and hence the insulation of the high-tension and other transformers must be carried out in the best possible manner. In order to prevent the high tension from breaking through insulation and getting back into the 100-volt primary circuit, a special "insulating converter" is employed. This converter consists of a primary connected to the 100-volt circuit, with four secondary coils, each giving 100-volt tension, all included within the same converter-box. The terminals of these 100-volt coils of the converter pass through switches and into the primaries of four high-tension coils, each capable of raising the potential to 15,000 volts. In addition to this there are two additional high-tension transformers of 2,000 volts each. Three of the 15,000-volt converters are not regulable, but one of them can be thrown on in steps of 3,000 volts each, while the 2,000-volt converters are graduated in steps of 100 volts. The readings are taken by means of a Thomson electrostatic balance reading up to 100,000 volts. The wires, of a uniform length of 6ft., have 3ft. of their length inserted in a tank full of water, the insulation, of course, extending above the surface. One terminal of the high-potential converter sets is connected to the tank, and the other terminal to one end of the wire to be tested, the other end of the latter being left free. Beginning with the lowest potential, the pressure is left on for 10 seconds. If the wire stands it, the next higher pressure is put on and so on, each potential being applied for 10 seconds. The current is thrown on with the safety switch; when the insulation breaks down the fuse blows. This arrangement has proved very satisfactory, and very rapid work can be done with it. In addition to the breakdown tests, it has been suggested by Prof. Barrett that it would be highly desirable to test wires after having been subject to the action of acids and ammonia as well as plaster. Although not definitely determined upon, it is probable that, with the aid of Prof. Barrett, a series of such tests will be carried out.

ELECTRIC SUPPLY COMPANIES.—I.

(Continued from page 341.)

WESTMINSTER ELECTRIC SUPPLY—ECCLESTON PLACE STATION.

The Eccleston-place central station of the Westminster Electric Supply Corporation is situated out of Eccleston-street, behind the Buckingham Palace-road, not far from the Victoria railway station. It is at this station that the Westminster Supply Corporation have their central offices—a handsome, lofty, and well-fitted suite of rooms. The system of supply is the same as the other Westminster stations—direct-current, three-wire distribution, with accumulator service at 100 volts.

The area of supply extends from Hamilton-place, Piccadilly, on the north, to the banks of the Thames at Vauxhall, on the south. It includes the favourite and fashionable districts of Hyde Park, Belgrave-square, Eaton-square, and other squares and streets in Belgravia, including Buckingham Palace, down to Chelsea Bridge, and away east to Vauxhall Bridge.

The engineer staff is as follows: resident engineer, Mr. C. O. Grimshaw; assistant engineers, Mr. W. Thompson and Mr. Garstin. The working staff consists of 19 men, composed as follows: three switchboard hands, three engine drivers, three assistant drivers, three firemen, two coal-trimmers, one battery attendant, one carpenter, and three general hands. The staff work regularly in three shifts of eight hours.

STATION.—The construction of the station is the same as that of Millbank-street, the building having been designed by the same architect for similar arrangements. The lofty engine-room is lined with white glazed bricks; the room above with concrete floor on girders, serving as workshop.

The size of the engine room is 93ft. by 38ft. The boiler-room at the side is 66ft. by 41ft. The accumulator-room is above the boiler-house and of the same size. There is ample room for doubling the plant in the present building; and there is space behind, 100ft. by 76ft., for more than doubling the present size of the entire station.

The concrete engine foundations are formed in one block 10ft. thick, but where space is left for other plant it is 2ft. less, so that the foundation bolts may be let in without disturbing the present foundations by simply filling up with concrete. The whole station is fitted with fire hydrants, and there is a 10-ton travelling crane overhead. An engineer's office occupies one corner of the engine-room. The switchboard, a very fine piece of workmanship, stretches along the wall on one side above the engines and dynamos. The engine-room is lighted by two 200-c.p. Sunbeam lamps in the roof, and several 16-c.p. lamps.

The chief difference between the Eccleston-place central station and that of Millbank-street lies in the boilers, the type of some of the engines, and of condensing apparatus.

BOILERS.—The boilers at Eccleston-place, instead of being of the water-tube type, are modified marine boilers. There are in all four boilers—three by Davey, Paxman, and Co., and one by Fraser. The gases in these boilers go into a combustion-chamber at the back, and are led forward through tubes to a smoke-box in front of the boiler, and then round the sides back into the main flue. The grate surface is 30 square feet, and the steaming capacity 5,000lb. of water per hour. The steam pressure is 150lb. per square inch.

A Green's economiser is used for heating the feed-water. What little water is required to keep up the condensed water to the necessary amount is obtained from the Chelsea water-mains, and a tank for this purpose is fixed above the pumps.

Duplicate steam-pumps, as at Millbank street, are used for the feed-water, and there is a double set of feed-pipes to each boiler. All water used in the boilers is pumped through a special water-meter.

The coal is the same as before mentioned—best Welsh smokeless—and is weighed on being brought in by the carts, on a roadway weighbridge, and again at every watch each barrowload is weighed on a portable weighing machine, and an exact record of the amount of coal burnt and of water used is kept for each watch.

ENGINES AND DYNAMOS.—The engines are of the Willans and Davey-Paxman make, and drive Crompton, Siemens, and Elwell-Parker dynamos.

There are three Willans II engines—triple-expansion, 200 i.h.p. each—one of which has just been put down in extension of the plant. Two of them drive Crompton dynamos at the speed of 350 revolutions. The third drives an Elwell-Parker machine.

Two Davey-Paxman "Windsor" engines of 150 h.p.—vertical, compound—also drive smaller Crompton dynamos; and two Willans G G engines—90 i.h.p.—drive Siemens dynamos, the latter being used as balancing machines on the three-wire network. All the dynamos are coupled direct to the engines, and are mounted upon the same bed-plate therewith.

The following are the details of the dynamos: The two large Crompton dynamos are 112 units, shunt-wound, four-pole machines, with drum armatures, giving 500 amperes at 225 volts; the two smaller machines (driven by the Davey-Paxman engines) are of the capacity of 250 amperes at 225 volts. The new Willans engine drives an Elwell-Parker two-pole dynamo of 112 units. The two Siemens machines give 300 amperes at 135 volts running at 430 revolutions. Ordinary sight-feed lubricators are used throughout.

All these sets of steam dynamos are under perfect control, are very economical, take but little room, and start very quickly—qualities the most desirable in central-station work. During a sudden fog the station can be started from complete shut-down within five minutes.

The condenser is placed in one corner of the engine-room, beneath the level of the floor, and serves for all the engines, all the exhausts being brought into one large steam-pipe. The ordinary type of surface condenser is used, made by the Central Marine Engine Works, the air-pump being placed alongside.

SWITCHBOARD.—The switchboard is of the same massive type as at Millbank-street, but has seven feeders in use, with capacity for eight. Pilot wires are brought back from every feeding point. The accumulator-room here being immediately behind the engine-room, the connections are made direct to the switchboard. The voltage on the houses is kept steadily at 100 volts.

Two recording voltmeters record the voltage continuously on each side of the circuit. Each dynamo has its meter, and two special Aron meters are connected with the batteries, one between positive main and the third wire, and the other between third and negative. These meters are made reversible, and register the difference of charge and discharge.

A potentiometer set, placed alongside the switchboard, mounted in a wooden case, is used for calibrating the instruments or for testing direct the potential at any point.

AN IMPROVED FORM OF INSTRUMENT FOR THE MEASUREMENT OF MAGNETIC RELUCTANCE.*

BY A. E. KENNELLY.

Of the methods that have been adopted for the measurement of magnetic permeance or reluctance of iron, the Faraday ring test with ballistic galvanometer is generally admitted to be the most accurate and reliable. It is, however, essentially a laboratory measurement, requiring considerable time in preparation, execution, and computation. For workshop measurements and comparisons, tractive and magnetometric methods have been employed with a convenience and facility usually obtained at some sacrifice in accuracy. Recently instruments have been used with success in which the reluctance of a sample bar of iron is compared with that of standard bars of soft Norway iron, notably the magnetic bridge of Mr. Thomas A. Edison exhibited at the Paris Exhibition of 1889, and the differential magnetometer of Mr. R. Eickemeyer. It is proposed to here describe a new instrument of this class, for which certain advantages may perhaps be claimed.

Fig. 1 represents the well-known galvanic arrangement of circuits in which two resistances, R_1 R_2, can be compared

* A paper presented to the Electrical Congress at Chicago.

by a null method. E_1 and E_2 are two equal and constant E.M.F.'s inserted in the conducting paths, A B and B C, of equal resistance. The galvanometer, G, connecting the junction, F, of resistances with the junction, B, of E.M F.'s will indicate no current when R_1 and R_2 are equal. The conductor, F B, corresponds to the neutral wire of a three-wire system of electrical distribution.

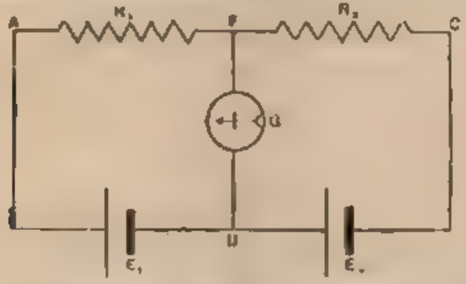


Fig. 1.

Fig. 2 represents the corresponding condition of magnetic circuits. A B C is a stout vertical frame of annealed Norway iron with two coils, M_1 M_2, wound with the same number of turns of wire, connected in series so as to develop with regulated constant current strengths equal definite M.M. forces. The upright G corresponds to the galvanometer arm in Fig. 1, while the bars, A F and F C, are test pieces of iron having a cross-section considerably smaller than that in the remainder of the circuit. One, A F, suppose, is a standard section made up of one or more bars of soft iron whose quality is known, while the other, F C, is the bar whose reluctance is required.

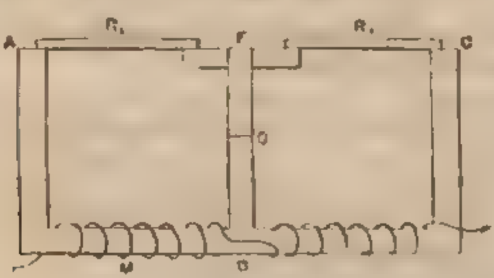


Fig. 2.

If the two reluctances, R_1 R_2, are equal, the magnetic potentials at F and B will be equal, and the bar, G, will remain unmagnetised when the coils, M_1 M_2, are excited. On the other hand, if R_1 and R_2 slightly differ, the potentials at F and B will not coincide, and magnetic flux will traverse the bar, G. Since the magnetic circuits are all closed, the leakage through the surrounding air will be

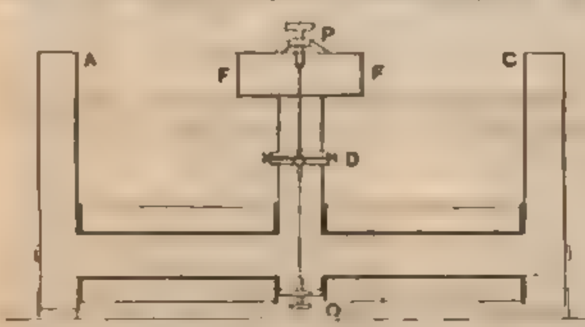


Fig. 3.

symmetrical and usually negligible, so that calling the flux through the main circuit Φ, and that through G, ϕ.

$$\phi = \Phi \frac{R_1 - R_2}{R_1 + 2G}.$$

In order to ascertain whether flux did traverse the bar G, we might, according to established principles,* cut in imagination an indefinitely narrow gap or crevice through G in a horizontal plane, and insert therein a magnet pole with apparatus to measure the tractive force to which it would be subjected. As the nearest practical approach to this plan, we can cut a gap across G $\frac{1}{16}$in. (0·16 centimetre) wide, and swing in the crevice a flat disc armature, carrying a steady feeble current and with an attached pointer or index close to a fixed scale. We then obtain in all essential features the instrument here to be described.

Fig. 3 represents to scale in front elevation the actual instrument. D is the disc armature, wound with 100 radial wires from centre to circumference. Half of this disc is always covered by the pole-pieces above and below it. The unifilar suspension attached to the points P and Q supplies a current of about 10 milliamperes to this disc. A sensibly constant tension upon the suspension is obtained by means of a spiral spring within the lower slide tube, and it can be readily shown by experiment or computation that small variations in the tension of such suspensions have a very small influence upon the torsional moment.

The *modus operandi* is as follows: A sample strip or flat bar of the iron to be tested is laid across the gap, F C. The breadth of the bar being conveniently 1in. (2·45cm.) and the height ½in. (1·27cm.), strips of soft iron to match this are laid across the gap, A F, in parallel, each being, say, 1in. by ⅛in. (2·54cm × 0·318cm.). If the disc circuit is then closed, and if there is no appreciable residual magnetism in the apparatus, the disc will remain uninfluenced and its index at zero. The field magnets are now excited in series with a suitable and measured current. The disc and pointer will now move to one side or the other about the axis of suspension according to the preponderance of reluctance between the two sides, and soft-iron strips have to be added or removed across A F until balance is restored. Generally balance will be found between two adjustments of cross-section at A F, and the proper amount can then be computed by proportional parts.

Steinmetz has shown* that from a series of such adjustments to equality between standard and sample bars at various excitations, the complete hysteresis curve of the sample can be deduced through the known valuations of the standard; but since a linear relation is found to exist between the reluctivity and magnetising force in iron above the critical intensity, two such observations are theoretically sufficient to determine the reluctivity of the sample for supra-critical magnetising forces.

The instrument can also be employed to readily indicate the retentiveness of sample bars of hard iron or steel. If after a balance has been obtained at a noted excitation, the excitation be withdrawn by interrupting the circuit of the coils, M_1, M_2, and the standard bar is removed, the residual flux from the test-piece will, disregarding some slight loss by leakage, pass entirely through the air-gap and disc at D. If the constant of the disc has been determined independently, the deflection of the pointer for the observed current through the disc will supply the amount of this flux.

If N denotes the number of turns in each spool;
I the current strength exciting the spools (amperes);
l the length of the test bar (cms.);
g the reluctance of the air gap at the disc (C.G.S.U.);
H_1 the magnetising force in the bar during excitation;
H_2 the magnetising force in the bar with excitation;

then the M.M.F. of excitation is in each coil $\frac{4\pi}{10}$ N I, and since the intensity in the test bar is considerably greater than in the field frame, the magnetising force brought to bear upon the test bar is nearly $\frac{4\pi}{10}\frac{N I}{l}$. After removing the excitation and standard bar, the observed residual flux encounters at the air-gap a reluctance, g, so that neglecting the comparatively small hysteresis of the soft-iron field frame, the counter M.M.F. at the gap is $-\Phi g$, representing an average demagnetising force in the bar of $-H_2 = \Phi g / l$ nearly, so that the relative values of flux density are readily found with different sample bars for any selected value of H_1, or, more closely, for any consequent ranges of $H_1 - H_2$.

By mounting two opposed parallel plane iron plates between the uprights, A and F, in such a manner that the length of air-gap between them can be adjusted by a screw, it becomes possible to measure the reluctance of a bar placed

* Clerk Maxwell, "Electricity and Magnetism," vol. ii., par. 396.

* *Transactions* of the American Institute of Electrical Engineers, vol. ix., p. 33, January, 1892.

between F and C by direct comparison with the reluctance of air. Trial has shown, however, that the additional contact surfaces involved the dissymmetry introduced into the two sides of the circuit, and the uncertain leakage error with large air-gaps probably more than offset the advantage to be derived.

The errors attending the use of the instrument are: (1) The variability of reluctance in the field frame; (2) errors in estimating the reluctance of the contact surfaces and the effective length of the test bar.

The first source of error depends upon the hysteresis in the iron of the field frame. It can be reduced to small limits by keeping the cross section of the test bar a sufficiently small fraction of the cross-section in the frame, thus bringing nearly all the reluctance of the circuit into the test bar. A correction can also be made for the outstanding frame reluctance.

The second source of error is common to all forms of permeameters in which straight test bars are employed in closed magnetic circuits. There will be a certain range of reluctance in the contact surfaces that can be kept in subjection by giving to those surfaces adequate area. There is also the more complex error due to misestimation of the effective bar length, for the reluctance of the bar will not only be encountered in the distance between the supports, F and C, but also by some portion of the length resting on the supports. The virtual length of bar included in the circuit will thus be a function of the intensity within it, and will not generally be the same for the test and standard bars.

The advantages of the instrument are: (1) Absence of hysteresis in the moving and indicating parts, which contain no iron; (2) great sensitiveness and control; (3) small reluctance in the narrow air-gap or path of differential magnetisation; (4) convenience in comparing retentive powers in steel.

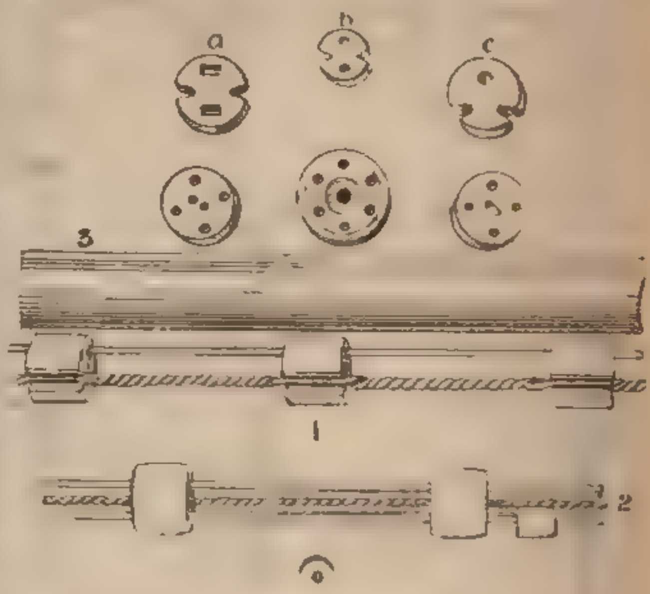
The writer desires to acknowledge his indebtedness to Mr. Thomas A. Edison, in whose laboratory this instrument was constructed.

The dimensions of a completed instrument are appended in detail: Core diameters, 5·08cm; core cross-section, 20·3 square centimetres; uprights, 5·08cm. by 5·08cm.; cross-section of uprights, 25·81 square centimetres; disc diameter, 7·6cm. external; entrefer, 0·16cm.; approximate reluctance of entrefer, 0·00826 C.G.S.U.; polar area above and below disc, approximate 20 square centimetres; mass of disc and pointer, 28 grammes; turns on each field spool, 3,213; diameter of suspension wire, 0·018cm.; deflection of pointer per ampere of current in disc, and per C.G.S. unit of flux through disc, 0·03deg.; thickness of aluminium disc, 0·035cm.; diameter of wire in disc radial winding, 0·035cm., silk covered to 0·042cm.; total thickness of disc, 0·077cm.; mean clearance of disc in air-gap, 0·0415cm.; winding 100 radial wires carried round on rim and re-entering at common channel, never passing into air-gap; available angular range of pointer, 140deg.

COOK, SMYTHE, AND PAYNE'S PATENT FIRE-PROOF SYSTEM OF CONDUCTORS.

These conductors were designed with the object of providing a mechanical system of conductors that would stand the same wear and tear that gas and water pipes are subject to when erected in the interiors of buildings. No vegetable substances are used in their construction and no inflammable materials. The conductors may be composed of tubes, strips, or wires placed inside tubes or tubular casings, and kept apart by means of insulators of suitable form fixed at intervals along the conducting tubes, wires, etc.

When arranged on the concentric principle a tubular strip is usually employed, to which insulating rings are fixed both inside and out. The tubular strip is not brazed nor soldered along the edges, but left open, and the rings are made to fit tightly inside and outside, so that they are held firmly in position by the mutual inward and outward pressure against the tubular strip. The inner insulators are provided with holes through which a rod or wire is afterwards drawn, the wire forming the lead and the strip the return for the current; these are then placed inside an outer tube that serves as a protection. The conductors can thus be made up in lengths in the workshop, and sent out ready for erection. Conductors arranged on this principle are very rigid, and are useful for vertical mains that may be used in large buildings to supply current to the different floors.

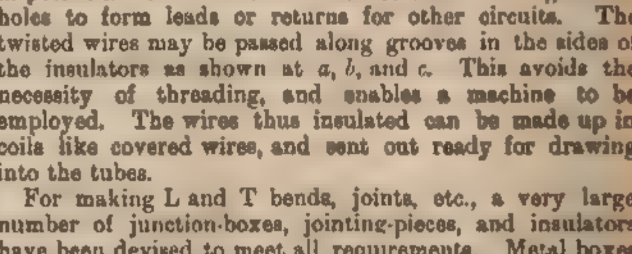


Figs. 1, 2, and 3.

Joints are made in a variety of ways by means of wires or strips soldered to the tubes. A useful plan, where the current is to be subdivided on a distribution board, is to solder the end of the tubular strip into a brass or copper ring with holes round the periphery fitted with screws under which connecting wires may be fixed for jointing to the fuses on the board.

Another method of insulating the tubes consists in the employment of small porcelain studs fitted into holes at intervals along the inner tubes. It is impossible to shift these studs out of position without breaking them.

When ordinary wires or flat strips are used, the insulators are made with one or more suitable holes through them to receive the former. If ordinary wires of circular section are employed, two are used; if a wire of rectangular section or a ribbon is used, one is sufficient. The insulators are first threaded on to the wires or strips at intervals, after which the latter are twisted, which fixes the insulators



Figs. 4 and 5.

in position. Other wires can then be drawn through other holes to form leads or returns for other circuits. The twisted wires may be passed along grooves in the sides of the insulators as shown at *a*, *b*, and *c*. This avoids the necessity of threading, and enables a machine to be employed. The wires thus insulated can be made up in coils like covered wires, and sent out ready for drawing into the tubes.

For making L and T bends, joints, etc., a very large number of junction-boxes, jointing-pieces, and insulators have been devised to meet all requirements. Metal boxes made of two or more parts—castings or stampings—and all interchangeable, may be used; these can be fitted on round the ends of the tubes, one half being usually fitted to the wall or ceiling, the other half acting as a cover that can be put on after the tubes have been placed in position, and the joints (if any) made.

L and T junctions are also used. Fig. 4 shows an L-junction for going round corners. Fig. 5 shows another made with press tools, and fixed together by means of rings, R, or clips slipped along the projecting edges or feathers that are turned up to receive them. This is shown open in Fig. 7.

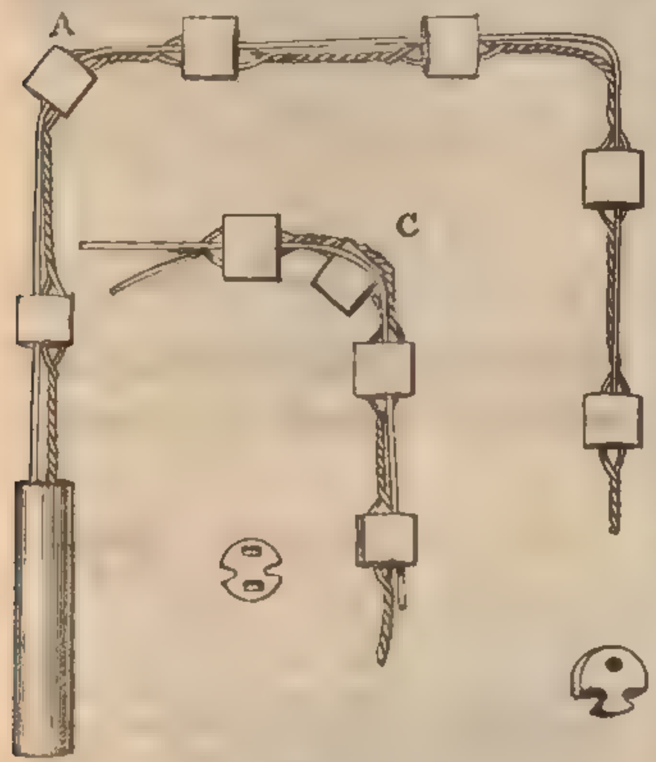


FIG. 6.

If a ring occurs exactly at a joint, as at A, Fig. 6, no further insulation is required; if not, as at B, an insulator with grooves in it may be inserted, if necessary, at C.

For very special work, where the exact position of the bend is known small rings may be threaded on to the twisted or to the other wire or wires, as at E and F.

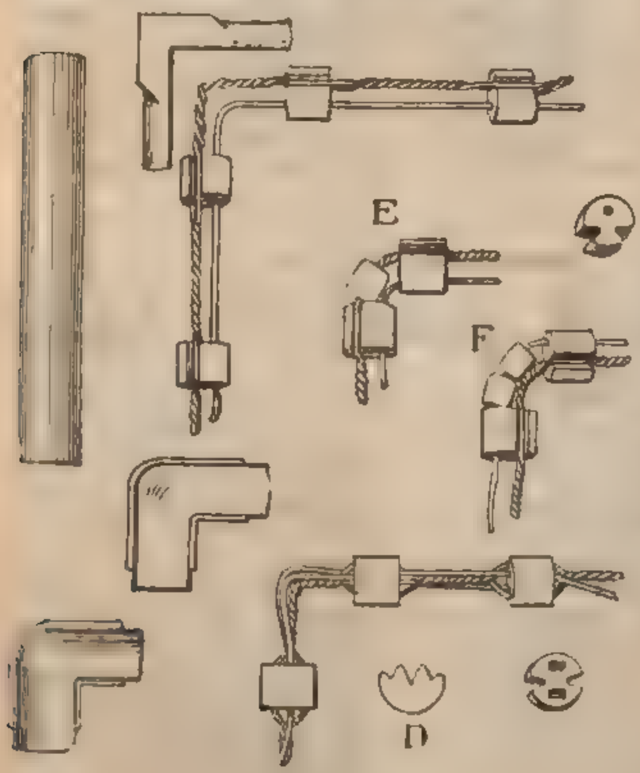


FIG. 7.

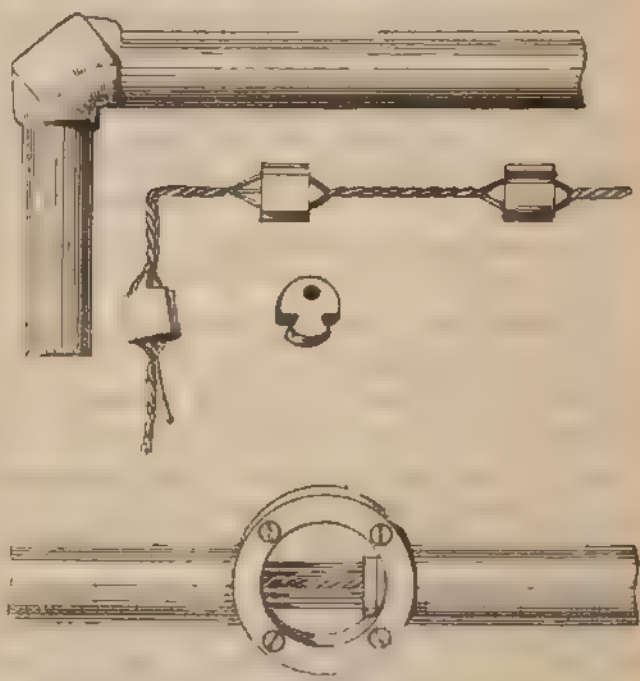
If it is desired to break the metallic continuity of the outer tube, a porcelain junction may be employed which has grooves inside that can be fitted round the wires; these are made in two parts with projections fitting inside the ends of the tubes, as shown in Fig. 8.

Fig. 9 shows another insulating junction, which acts also as a support; these are most convenient where ceiling roses are used, or other similar fittings, in combination with the tubes.

Special attention has been given to the construction of rows of lights when fixed to tubes whether fixed or portable, such as those used for showrooms and shop windows, and for the floats, battens, or lengths employed for stage-lighting. A long tube with 50 lights arranged in this manner has recently been erected in the new Victoria Concert Hall at Langham-place for lighting the orchestra.

The fireproof nature of the arrangement is one of the chief advantages claimed for the system. The conductors can also be erected in hot places—boiler-houses, engine-rooms, factories, etc.—without any risk of the insulation being injured by the heat, as is the case with rubber-covered wires.

With regard to the permanent character of the insulation the inventors wish to point out that the conditions of working where bare conductors are used for interior wiring are usually the reverse of those met with in connection with underground conduits. The temperature of a conduit is often lower than that of the air above, and when moist air finds its way into a cold conduit there may be some condensation; the interior of a building, however, is usually warmer that it is outside, and this condensation is not found to take place.



FIGS. 8 AND 9.

There are usually many places in an installation where the lamps are fixed close to or on the tubes, and when lighted acted as small stoves, keeping the tube warm and promoting circulation of the air.

When the conductors are erected in boiler-houses, or near furnaces or ovens, or laid in recesses in walls or floors near hot-water pipes, the insulation, if anything, is improved. In places exposed to the heat of the sun, and in hot countries generally, these conductors can be employed where shellac, paraffin, wax, and rubber insulation would be unsuitable.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE II.

(Concluded from page 355).

The original project for utilising the motive power of the Rhone at Geneva, partly for pumping a supply of water, partly for motive power for industry, comprised 20 turbines of 3,000 h.p. each, or an aggregate of 6,000 h.p. Fourteen of these were at work in 1892. Four more of somewhat larger size will, it is expected, be constructed by 1898. When these are at work the whole available water power in Geneva will be utilised. But it is foreseen

* Howard Lectures delivered before the Society of Arts.

that the demand for power will not then have been satisfied. The total receipts for the installation reached £22,500 in 1891, and were increasing £2 200 annually The Municipality of Geneva has determined to provide for future demands, and plans are being studied for utilising 12,000 h p at a point on the Rhone six kilometres below Geneva, whence the power will be distributed electrically. At Biberest, near Soleure, Messrs Cuenod, Sautter, and Co have utilised 360 h p., and transmitted it 28 kilometres electrically At Genoa water power due to surplus fall along a line of water main has been utilised at three stations The greater part of the energy is transmitted to Genoa for electric lighting and power purposes.

These are cases where water power has been utilised and distributed which are actually in operation; but there are many other schemes projected: one is for utilising 10,000 h p on the Drause, near Martigny; another to utilise 20,000 h.p. at a point 17 kilometres above Lyons In Sweden, there is a project to transmit power from the Dal River Fall at Mansbo, to the Norberg mining district, a distance of 10 miles; another to transmit the power of the Strup Waterfall, on the Judal river, to the town of Ostersund, a distance of 11 miles. Projects for utilising the Falls of Trollhatan, and the River Motala to supply power to Gothenburg and Nord Koeping, have also been studied

Water Power in the United States of America It is in the United States of America that water power is most largely used, where it is in most direct competition with steam power and where data for a comparison of their relative advantages can best be obtained Interesting data as to the extent to which water power is utilised in the United States are given in a paper by Mr G F Swain, and read before the American Statistical Association * The money value of the water power utilised in the United States is very considerable From the returns of the tenth census it appears that in 1880 there were 55,000 waterwheels and turbines of an aggregate of 1 250,000 h p At £5 per annum the water power utilised is worth £6,250,000 a year. The comparison of the relative amount of water and steam power is interesting Taking the whole of the United States, 36 per cent of the power used in manufacturing was at that date water power, and 64 per cent steam power

In certain industries the proportion of water power was greater In the manufacture of cotton and woollen goods, of paper, and of flour, 760,000 h p. derived from water, and 515,000 h p derived from steam, were employed In the North Atlantic division 4 81 water horse power are utilised per square mile.

Division.	Water power per cent.	Steam power per cent.
N Atlantic	43 1	56 9
S. Atlantic	49 5	50 5
N Central	22 2	77 8
S. Central	22 5	77 5
Western	35 3	64 7
The United States	35 9	64 1

Fig 12 is a map taken from Mr Swain's paper, which shows that over a considerable area of the United States the water power used exceeds the steam power It should, however, be pointed out that in the decade 1870 80, during which the total power used increased 45 per cent., 9 per cent. of the increase was due to water power, and 91 per cent. to steam power. It is possible that under the new conditions now obtaining, the present decade will show a greater relative increase of water power.

American Method of Distributing Water Power.—The method in which water power is distributed in America to a number of consumers is almost peculiar to that country A water power company is formed, which undertakes the construction of the permanent works, such as a river dam, sluices, and distributing canals. In New England there are five water power stations where more than 10,000 h p. is utilised during working hours, and 13 stations where more than 2,000 h p. is utilised The water is distributed to mill owners, who construct the turbines and pay a rental to the water power company proportional to the amount of water used The earliest application of this system was at Paterson, New Jersey, where the Passaic river furnishes about 1,100 h p night and day † At Lowell Massachusetts, the utilisation of the water power began in 1822. The Merrimac river has a fall of 35ft., and furnishes at the maximum about 10,000 h.p. during the usual working hours. At Cohoes, in the State of New York, the Mohawk river has a fall of 105ft. It could furnish about 14,000 h p during working hours, but it is only partly utilised at present. At Manchester, New Hampshire, the Merrimac has a fall of 52ft., and furnishes at the minimum about 10,000 h p during working hours. At Lawrence, Massachusetts the Essex Company built a dam forming a fall of 28ft., and obtaining a minimum power of 10,000 h.p during working hours. At Holyoke, the Hadley Falls Company built a dam forming a fall of 60ft., and rendering a power of 17,000 h.p. available during working hours

To indicate the magnitude of some of these works, it may be stated that at Lawrence the masonry river dam is 900ft. long and 32ft. in height. The cost was £50,000. From this dam two canals extend down stream, one on each bank, and between these canals and the river are located the mills, occupying the entire river front. On the north side the mills extend for a distance of more than a mile. The cost of the canal on the north side, 5,330ft. in length and 100ft. in width at the upper end, was £50,000 The canal on the south side 2 000ft in length and 60ft in width, cost £30,000 The case of Holyoke may be described in somewhat greater detail. The whole of the factories in the town are worked by water power, and the system is strictly a distribution of power to many consumers at a rental strictly proportional to the amount of power used, although the power is actually developed in the mills by turbines belonging to the millowners The first weir or dam was built in 1847, but it was carried away. A second dam of cribwork was built in 1849. In 1868 an apron was constructed to protect the rock immediately below the dam, since then, Mr. Clemens Herschel * has carried out extensive repairs of the dam under conditions of singular difficulty and with great success. The structure is now 130ft. in width, 30ft. high and 1,019ft in length From above the weir a first canal supplies water to the highest line of mills. From these mills, after driving turbines, the water is discharged into a second canal, which is a supply canal to a second line of mills. The tail races of these mills discharge into a third canal feeding a third line of mills and there are still other mills worked by the water before it returns into the river. The power now utilised is 15,000 h p. by day, and 8,000 h p. at night. Altogether there are about 53 mills

With the grant of land for a mill there was leased the right to use a definite portion of the water. A "mill power" is defined as 38 cubic feet of water per second on a fall of 20ft during 16 hours per day. This gives about 63 effective horse power on the turbine shaft. At the time when Mr. Herschel became engineer to the water company the water was used extravagantly By

Fig 12.

introducing a system of testing the turbines, and by establishing gauges at each mill showing at any moment the amount of water passing through the turbines great economy in the use of the water was secured. The water saved was sold for surplus power. Observations of the amount of water used by each turbine and the difference of the level in the head and tail race are made once in the day and once at night. Three inspectors are engaged exclusively in this work. From the daily observations the amount of power used by each mill is calculated. A portion of the power is charged for according to the terms of the lease at a fixed rental. The balance is charged for as surplus power In times of very low water, the power is restricted to the amount guaranteed in the lease.

Relative Cost of Water and Steam Power in the United States.—In some cases local conditions are so favourable that water power can be developed at an almost nominal cost. In other cases unforeseen contingencies have led to expenditures which have made the cost of water power excessive; greater, in fact, than that of steam power. Mr. Swain puts the average cost of steam power in the States, in favourable localities, at £4 per horse power per annum, and that of water power at about £2 per horse power per annum. Both these estimates are so low that it may be suspected that they are based rather on the nominal power of the plants than on the average actual horse power used throughout the year. The cost of water power, however, varies greatly Mr Swain states that while in the North West of the United States the cost for interest, depreciation, and water rental is about £2 2 to £2 5 per horse-power per annum, in New Jersey it is from £12 to £15 That

* "Statistics of Water Power Employed in Manufacturing in the United States." By G. F Swain Publications of the Americal Statistical Association, March, 1888.

† J. B. Francis, *Trans. Am. Soc. of C.E.*, vol. x., p. 189.

* "On the Work done for the Preservation of the Holyoke Dam in 1885," by Clemens Herschel, *Trans. Am. Soc. Civil Engineers*, vol. xv., p. 543.

water power is used at all at a cost so large as this proves that it has advantages of convenience compared with steam power which balance some excess of cost.

It is somewhat difficult to arrive at a precise knowledge of the cost of water power in the great works in America, because of the gradual way in which they have been developed, and the want of complete data as to the amount expended. Mr. C. E. Emery,* who is probably rather prepossessed in favour of steam power, has made the following estimate of the cost of water power at Lawrence. He puts the total cost of the structural works at Lawrence at £200,000, and the power utilised as equivalent to 13,000 h.p. for 10 hours daily throughout the year. That makes the cost of structural works £15·4 per horse power. The cost incurred by the mill owners in erecting turbines, sluices, etc., he puts at £9 per horse power of the turbines, or £13 per average horse power actually utilised, the turbines being generally constructed to yield surplus power in times of emergency. This makes the total expenditure £28·4 per average horse power utilised 10 hours daily throughout the year. He allows $2\frac{1}{2}$ per cent. for depreciation, $1\frac{1}{4}$ per cent. for repairs, $1\frac{1}{4}$ per cent. for taxes, 10 per cent. for interest, and 2 per cent. for working expenses, or, altogether, 17 per cent. on the capital expenditure. This makes the annual cost of a horse power at Lawrence £4·7 per annum, which he takes to be about the same cost as that of steam power with economical engines, and coal at 8s. to 12s. a ton. No doubt, however, in many cases water power can be utilised at a less cost per horse power than that incurred at Lawrence.

Cost of Water Power at Geneva.—It appears that at Geneva, for the first groups of turbines erected, of 840 h.p., and for the river works then completed, the capital cost amounted to £60 per effective horse power. The groups of turbines subsequently erected have cost only £19 per horse power. The mean cost, when the present works are completed, will amount to £27 per effective horse power. In this case the water costs nothing. If we allow 5 per cent. for depreciation, repairs, and working expenses, and 10 per cent. for interest on capital, the cost per horse power per annum will only amount to £4. In the new works below Geneva where 12,000 h.p. are to be utilised, it is estimated that the whole cost for turbines and structural works will amount to £60 per horse power for the first 2,400 h.p. When the whole installation is completed the capital cost will be only £27 per horse power.

STORAGE OF WATER POWER.

The need of storing power derived from waterfalls arises out of different considerations from those which apply in the case of steam power. A river flows day and night with an energy which varies according to the season but not from hour to hour. The work to be done necessarily varies in almost all cases and in most cases there is no demand for work to be done during half the 24 hours. If no means of storage is found a large part of the natural supply of energy flows away and is wasted. But there is another reason. In the case of water power nearly the whole cost of the power is due to interest and depreciation on the permanent works, machinery, and structures, nearly nothing is due to daily working expenses. With steam power only about one third or half the cost is due to permanent charges, and two thirds to half arises out of wages and fuel. If the engine stops for 12 hours out of the 24, coal and wages are saved, and though the cost per horse power is greater, it is only moderately increased. But if water power machinery stops for 12 hours out of the 24, there is no sensible diminution of working expenses, and the cost per horse power is doubled. At some of the American water power stations, an inducement is held out to consumers to work day and night by charging a lower rate for power at night. In other cases the difficulty is met by storing the night water to be used by day, so that the amount of power which can be supplied during working hours is doubled. It will appear in the course of these lectures, that one of the most characteristic advantages of water power, as compared with steam power, is that the former permits the storage of energy by means not costly or difficult. It is the facility of storing energy by raising water to elevated reservoirs which, in some cases, makes it profitable to pump water to be used afterwards for power purposes.

There are two distinct methods of storing energy in hydraulic systems—accumulation storage and reservoir storage. Perhaps, on superficial consideration, it would hardly have appeared likely that it could be profitable to pump water to be used for power purposes. There are cases where it is so—one of these is the system of hydraulic transmission originated by Lord Armstrong. The system of hydraulic transmission is used, and can only be used advantageously to work a great number of intermittently working machines. A single engine, working almost continuously, pumps water which actuates a great number of intermittently working motors. Naturally, the fluctuation of demand for power varies a great deal, and storage is almost essentially necessary. Perhaps it is to the invention of the accumulator—a means of storing the energy of pressure water—that the success of the system of hydraulic transmission is chiefly due. The hydraulic accumulator is simply a vertical cylinder with a heavily loaded plunger, into which the water is pumped till it is required, and from which it is discharged by the descent of the plunger. Let A be the area of the plunger in square feet, P the total load on it in pounds. Then $p = P/A$ is the pressure at which the water is delivered in pounds per square foot. If h is the length of stroke of the accumulator plunger, then $A\,h$ is the greatest quantity of pressure water it will store, and $p\,A\,h$ foot-pounds is the energy stored when it is fully charged. The pressure used in systems of hydraulic transmission is generally 750lb. per square inch. Now, one of the very large accumulators of the London Hydraulic Power Company has the following dimensions: diameter of plunger, 20in.; stroke, 23ft. At 750lb. per square inch, this accumulator, large as it is, stores only 2·4 horse-power hours—a comparatively insignificant quantity. The cost of this accumulator, reckoned on the capacity for storing energy, must be very large indeed. What makes the accumulator so important is that its rate of discharge is very great. It would probably supply 100 h.p. for $1\frac{1}{2}$ minutes. Hence, like the flywheel, the use of the accumulator is limited by its costliness to meeting fluctuations of demand in short periods of time. It cannot be used to average the variations of demand through the 24 hours. It is superior to the secondary battery in that the rate of supply of stored energy is not limited.

If a suitable site can be found, reservoirs can be built of very, very large capacity at a cost not large per cubic unit stored. Let A be the mean area of the reservoir, h the variation of depth in the reservoir, and H the height of the reservoir above the hydraulic motors driven by the water (foot units). Then the volume in the reservoir when full is $A\,h$, and the gross energy stored is—$G\,A\,h\,(H - \frac{1}{2}h)$ or $G\,A\,h\,H$ nearly. At Zurich, for instance, the storage reservoir contains 353,000 cubic feet at an elevation of 475ft. above the motors. It therefore stores 5,284 horse power hours. At both Geneva and Zurich very remarkable and extensive systems for utilising and distributing water power have been for some time in successful operation, and to these attention will be directed more than once in these lectures. In both cases the water flowing out of a large lake with a comparatively small fall, is utilised to carry a very considerable and valuable power. In both cases it has been found convenient and economical to use the low pressure turbines to pump water to a reservoir at a great elevation and to use the pumped water for ordinary motor purposes. Data may be taken from the Geneva installation, though the works in both cases are similar, and both have been financially successful. At Geneva, the Rhone flowing out of Lake Leman has by skilful arrangements been made to afford a clear fall varying from $5\frac{1}{2}$ft. to 12ft. At Geneva there have been erected on this fall or shortly will be erected, 18 low pressure turbines, giving an aggregate power of over 4,000 h.p. These turbines are used primarily in pumping a supply of water for Geneva; but since 1871 there has grown up a system of using water from the town mains for motor purposes in Geneva, and it is an important secondary function of the low pressure turbines to pump this water used for motor purposes. To begin with, it may be pointed out that low-pressure turbines, together with the building and permanent works required to create the fall, are very costly. It is desirable that to reduce the permanent charges on the energy furnished, they should work as long hours as possible. Further, the total power furnished is even now insufficient for the work to be done, and it is necessary that water power should not flow to waste; but, even for other reasons, it became necessary to use storage of energy before the present exigencies arose. In the earlier period of the enterprise to maintain constant pressure, in spite of the fluctuation of demand on the mains, it was necessary that the turbines should be constantly pumping in excess of the demand. The surplus was discharged through a relief valve, and involved a constant waste. To meet fluctuations of pressure, four large air vessels were constructed, 5ft. in diameter and 39ft. high. With these the working was smooth and successful but necessarily wasteful. When the electric installation was erected at Geneva, and driven by turbines actuated by the pumped water, the necessity of storage became more evident. At four kilometres from Geneva a site was found at an elevation of 390ft. above the lake where a reservoir could be constructed. The reservoir contains 453,000 cubic feet, and stores, therefore, 5,573 gross horse power hours of energy. Allowing for the loss at the motors driven by the water, the effective energy stored may be taken at 4,180 horse power hours. The reservoir is a covered reservoir of expensive construction. But its cost does not exceed £2·4 per horse power hour of energy stored. It is a work requiring little maintenance, and it hardly adds 3s. per annum to the cost of a horse power supplied. On the other hand, the energy stored would, without it, have gone to waste, and for this a rental is obtained of £8 per annum.

There is now in London an admirable system of hydraulic power distribution perfectly adapted to the special purposes to which it is applied, and mechanically and financially successful. But it is a system of limited applicability. Large as it is, the number of renters of power is under 2,000, and the maximum pumping capacity of the stations at present erected is 1,500 effective horse power. In the comparatively small town of Geneva, with one-eightieth of the population of London, there is a system of power distribution as large and of more varied usefulness than the system in London. There were there, three years ago, 137 motors, aggregating 280 effective horse power on the low pressure mains, and 79 motors aggregating 1,284 h.p. on the high pressure mains. The use of the hydraulic power was increasing at the rate of nearly 200 h.p. per annum. Lastly, the power in Geneva is distributed to ordinary consumers at one-fifth and for electric lighting at one-twelfth the London price.

Perhaps it is fair to add that in London there are 2,500 gas-engines, which represent a considerable aggregate power, virtually supplied from a central station. Nevertheless motive power is more generally, and more cheaply, distributed in Geneva than in London. No doubt local conditions have favoured the adoption of plans for distributing power in Geneva; but, perhaps, it has not yet been fully recognised in London what an advantage cheaply distributed power is. Perhaps, when this is better recognised, means may be found to make motive power more available as a purchasable commodity.

* "The Cost of Steam Power," by C. E. Emery, *Trans.* Am. Soc. of Electrical Engineers, March, 1893.

MANCHESTER.

The following are the regulations for wiring and fittings in connection with the supply of electric current.

The Corporation will not supply or fix any internal fittings beyond the meter on consumer's premises.

It will be necessary that the wiring on consumer's premises shall conform to certain conditions and tests both for the protection of the Corporation and also for the protection of the consumer himself. The following provisions, however, are intended for the protection of the Corporation, although they are incidentally beneficial to the particular consumers, but the Corporation will take no responsibility in respect of testing a consumer's premises for his own protection.

1. Except by special arrangement, not more than 80 16 c.p. lamps may be supplied at 100 volts from a single pair of service terminals. When more lights are to be supplied, they must be divided between different pairs of the five wire conductors. If this rule is departed from, there is danger that the pressure of the supply will not be so uniform as it should be.

2. All conductors must be protected by cut outs, which must be competent to cut off the current if this exceeds the normal current by 50 per cent. It must be impossible for an arc to be maintained between the terminals of any cut out.

3. The switches must be so constructed that they do not heat with the full current; that it is impossible for them to remain in a position between full on and full off; and that it is impossible for an arc under any circumstances to be maintained on the switch.

4. Before taking on any consumer, his premises will be tested for insulation, and they will be tested from time to time to ascertain that the insulation has not deteriorated. The Board of Trade require that any consumer whose insulation is less than 10,000 ohms shall be cut off, and the Corporation incur responsibility by neglecting to cut off such consumer. This is not sufficient insulation except in the cases of very large consumers, and the following which is taken from the Phœnix Fire Office Rules, must be adopted:

"In any electric light installation in which the current is continuous, and has an E.M.F. of 200 volts or under, the insulation resistance over the whole installation should not be below the following:

Installation of	25 lights	...	500,000 ohms
,, ,,	50 ,,	...	250,000 ,,
,, ,,	100 ,,	...	125,000 ,,
,, ,,	500 ,,	...	25,000 ,,
,, ,,	1,000 ,,	...	12,500 ,,

"When the lights are proportionate between the above numbers, then the insulation resistance should be correspondingly proportionate.

"The insulation resistance of the separate circuits of the installation should also be taken, and should be in accordance with the above table."

In cases where the supply is at more than 200 volts, the insulation must be doubled in each case.

All wiring, electrical fittings, and appliances of every description, situate on any premises intended to be used in connection with the supply of electricity from the Corporation, must be approved by the Corporation or their authorised officer before the installation is connected with the electric conductors belonging to the Corporation.

The Corporation do not undertake any responsibility for the efficiency and proper execution of any work on consumer's premises. The inspection and insulation test is made for the purpose of the Corporation only.

No installation will be connected to the supply conductors where wires are hung in a temporary or loose manner. Wires under floors are not desirable. Staples should not be used.

The Corporation will convey their electric conductors through the outer wall of buildings to be supplied and terminate with a meter at a suitable position to be determined by the Corporation engineer; and after the connection has been made no alteration shall take place until due notice has been given, otherwise the supply is liable to be stopped.

The consumer must give not less than 48 hours' notice to the Corporation in the event of being desirous of having the meter removed, and shall in no way interfere or tamper with the meter, the Corporation being empowered to withhold the supply upon infraction of this rule.

Inspection of meters will be made periodically.

The Corporation inspector is entitled to free access at all reasonable times to take readings of the meter, and to inspect or repair any work in connection with their service.

The reading of the meter shall be taken as the quantity of current used in each quarter. Should the consumer dispute such reading, it may be officially tested, and if in any quarter the meter is found incorrect, the Corporation will add or deduct for such quarter only; and if the official test certifies the meter as correct, the consumer shall bear all expense of the testing.

The attention of the consumer is drawn to the fact that most of the fire insurance companies issue regulations as to the laying down of electric light work, and the due observance by the consumers of those regulations when the installation is first laid down will probably save subsequent annoyance and expense.

Western and Brazilian Telegraph Company.—The receipts for the week ended October 13 were £2,941.

BUSINESS NOTES.

Newport.—The telegraph system has been extended to Nantyglo.

Hastings.—The new offices of the Board of Guardians are to be electrically lighted.

Southport.—The Town Council propose to acquire the tramway system in the borough.

Oldham.—The directors of the Yew Spinning Mill have decided to light their mill by electricity.

Radcliffe.—The Local Board have appointed a committee to consider the question of electric lighting.

The Royal Exchange.—Messrs. J. G. Statter and Co. are carrying out the electric lighting of the Royal Exchange.

Steamer Lighting.—The new ferry steamer for the London County Council, the "Hutton," is lighted by electricity.

Newport.—We believe that the specifications for the electric lighting of Newport will be out at the end of the month.

Liverpool Overhead Railway.—The traffic receipts of the railway for the week ending the 8th inst. amounted to £666.

Chalfont St. Giles.—A turbine has been laid down to drive a dynamo supplying current for lighting "Straton Chase."

New Business.—Mr. Malcolm Sutherland has started in business as a consulting electrical engineer at 377, Bath-street, Glasgow.

Ipswich.—A petition for the winding up of the Ipswich Electricity Supply Company, Limited, is to be heard on the 25th inst.

Fire.—A fire has done considerable damage at a shop attached to the Kennington New-street electric station of the City and South London Railway.

Change of Address.—The address of Messrs. Babcock and Wilcox, Limited, is now 147, Queen Victoria-street, instead of 114, Newgate-street, as formerly.

Hertford.—The General Committee of the Corporation have decided to postpone the further consideration of the proposed electric lighting scheme until next year.

Taunton.—At a meeting of the Town Council last week the bill of expenses that had been incurred in obtaining the provisional order for the electric light company was made public.

Pupil.—The electrical engineer to the Corporation of Brighton has a vacancy for an articled pupil at the borough electricity works. Applications to be sent to the electrical engineer.

Hull.—The Hull Corporation are prepared to take one improver into their electric light works, for a period of two years, at a premium of £30. Particulars are given in our advertisement columns.

St. Pancras.—The Vestry have accepted the tender of Messrs. E. Houghton and Son, of Stroud Green, N., for the addition of new buildings to the station in Euston-road. The tender amounted to £1,876.

St. James's and Pall Mall Company.—The electric current sold by this Company during the quarter ended September 29 last amounted to £4,820, as against £5,764 for the corresponding period of 1892.

Chester.—The members of the Town Council have discussed a proposal to adopt the Hop Pole Paddock as a site for an electric lighting station for the city. After considerable discussion the proposal was carried.

Vacancy.—Applications may be sent to the secretary of the Scottish House-to-House Electricity Company, Limited, 109, Hope-street, Glasgow, for the position of manager of the company's new generating station at Coatbridge.

Cleckheaton.—The clerk to the Local Board has reported that the Local Government Board has sanctioned the borrowing of a further sum of £1,750 for the completion of the public offices, together with £670 for the electric lighting.

Paignton.—The Local Board have received further offers from firms for providing electric lighting, and Messrs. Parnell, Bailey, Rabbich, Drew, and Bridgman have been appointed a special committee to consider the whole subject and report.

Aberdeen.—The School Board intend to apply to the Town Council for an extension of the electric light main along King-street as far as the Board's house, and in that case to obtain estimates for an installation of the electric light in the Board's office.

Dewsbury.—The Board of Guardians have resolved to give the Electric Lighting Committee power to consult an electrical engineer in respect to the scheme proposed for lighting the new infirmary and the workhouse. The expense proposed to be entailed is about £2,100.

Telephony between Barry and Cardiff.—A subsidiary line is in course of construction, and will be completed shortly between Cardiff and Barry, in order to provide facilities to cope with the rapidly increasing volume of telephonic business at the post office at Barry Dock.

St. Olave's.—The Board of Works have given the contract for the electric lighting of the new offices referred to in our last issue to Mr. W. Mackie, of Turnmill-street. He is also installing the electric light in the new St. Olave's Grammar School which is being erected in Tooley-street.

City and South London Railway Company.—The receipts for the week ending October 15 were £849, against £902 for the same period last year, or a decrease of £53. The total receipts for the second half year of 1893 show an increase of £356 over those for the corresponding period of 1892.

Personal.—Mr. R. Wynne, of Newcastle-upon-Tyne, has been appointed resident electrical engineer to the Corporation of Bury. The appointment has been made of Mr J. E. Edgcome as resident engineer and manager at the generating station at Kingston, at a salary of £156 per annum.

Abercarn.—At the ordinary monthly meeting of the Abercarn Local Board a letter was read from the Blaenavon Chamber of Trade asking the Board's co-operation in establishing telephonic communication between the Eastern and Western Valleys. It was decided to ask for particulars as to cost.

Barnet.—The chairman of the Barnet Local Board has received from the manager to the Electric Installation Company, Limited, a letter asking for an opportunity to meet the Board to discuss a scheme for taking over the lighting of the town. The Board have decided to hear what the company have to propose.

Telephony.—The National Telephone Company have made arrangements whereby their exchanges at Plymouth, Exeter, Torquay, and Paignton will be continuously open day and night (including Sundays and holidays), and the trunk wires between those places will also be always available for communication.

West India and Panama Telegraph Company.—The receipts for the two weeks ended October 15 were £373 less than for the corresponding period. For the six months ended June 30 last the directors recommend the full dividend on the preference shares and 1s. per share on the ordinary shares, after having placed £3,000 to reserve.

Ramsden, Camm, and Co., Limited.—This Company has been registered with a capital of £50,000 to take over the businesses carried on at Leopold Works and Robin Hood Works, Brighouse, under the styles of "Ramsden, Camm, and Co." and "S. H. Byrne," and to carry on the business of wire drawers, manufacturers and galvanisers, etc.

Electro-Tanning.—Mr. L. A. Groth has removed from his London address, 3, Tokenhouse buildings, E.C., to Orbe, near Lausanne, Switzerland, where he has taken the technical management of the largest tannery there which is now being enlarged and reconstructed entirely according to "Groth's system" of tanning by aid of electricity.

Falmouth.—The chairman of the Lighting Committee of the Urban Sanitary Authority has reported that he has, in compliance with the resolution passed at the last meeting, requested Messrs. Veale and Co., electrical engineers, St. Austell, to prepare a report on the electric lighting of Falmouth main streets, and that he has received the report. The report is to be considered by the entire Authority.

Shoreditch.—A Mr. W. T. Baker has forwarded to the Shoreditch Vestry plans and copy of a new scheme for the erection of baths, electric lighting station, and dust destructor. He claims that there was every possibility that his scheme would recoup itself out of its own earnings. The plans have been sent to the Electric Lighting Committee and the Baths and Washhouses Commissioners.

Islington.—Mr. Gay, the electrical engineer to the Vestry, is now busily engaged in viewing the various sites under the consideration of the committee, assisting in the negotiations for those sites, and considering the question of distribution, with a view to the preparation of a scheme for distributing the light. He will then prepare specifications for mains, plant, and works, and get out estimates for loans.

Dover.—The electric light has now been introduced into the mills of Messrs. Chitty, of the Charlton Flour Mills. The premises are fitted with 126 incandescent lights of 16 c.p., whilst the outside court and entrance yard are illuminated by two of 60 c.p. The current is obtained from a dynamo on the premises, driven by the ordinary mill machinery. The installation has been carried out by Messrs. Christy Bros., of Chelmsford.

Rugby.—Rugby School and the boarding houses connected with it are now lighted by electricity. A dynamo, capable of generating current for 1,000 lamps, has been supplied by the Brush Company, and it is run by a Dowson gas engine of 40 h.p. nominal. As accumulators have not been provided, a smaller engine and dynamo have also been put in to run when the load is light. A local telephone system is suggested to be provided.

The Fowler-Waring Cables Company, Limited.—This Company is now represented by Mr. Alfred E. Garbutt in the North of England; by Mr. J. Vincent Swindells in Manchester and Midlands district; and by Mr. Charles Parker in the Eastern and South Eastern districts, including London. Offices will shortly be opened in Newcastle as the centre of the Northern district, and in Manchester as that of the Manchester and Midlands district.

Temporary Electric Lighting.—Messrs. Vaughan and Brown, of 15, 16, and 17, Kirby street, London, E.C., have made arrangements for lighting by electricity the Agricultural Hall during the holding of the three exhibitions—namely, the Brewers', the Confectioners', and Stanley Shows. The hall will be illuminated with 50 arc lamps, the current to be generated by a Brush dynamo driven by a 20 h.p. Stockport gas engine lent by Messrs. Bilbie, Hobson, and Co.

Buxton.—A letter was read at a meeting of the Local Board last week from Mr. C. E. Baker, Local Board's Association, asking if the Board contemplated any parliamentary proceedings next session on the subject of electric light. Mr. Hulme asked what had become of the Electric Light Committee that was appointed a long time ago. Mr. Lawson said it had "gone out." Mr. T. Cooper said the committee referred to had power to spend £20, and Mr. Lawson observed that they ought to be surcharged if they did so.

Cardiff.—The capstone of the chimney stack erected to serve the Cardiff electric lighting station at Canton Common was laid on Tuesday by the Mayor (Councillor W. E. Vaughan). The stack is 150ft. in height, and has a diameter of 13ft. at the top and 26ft. at the base. It is built of Ebbw Vale bricks, with facings of buff and red pressed bricks. No fewer than 240,000 bricks and no less than 80 tons of mortar have been utilised in the construction of the chimney.

Rochester.—A notice from the Chatham Electric Lighting Company as to opening pavements to connect Mr. Bomrose as a customer, was considered at a meeting of the Town Council last week. It was resolved that the pavements must be put into proper condition after the execution of the works, and that the town clerk call attention to the fact that the amounts due from the company to the Corporation are still in arrear, and that they must be paid at once.

Bolton.—The Gas and Lighting Committee of the Bolton Corporation invite tenders, as will be seen from our advertisement columns, for the supply and erection of switchboards, accumulators, connections, etc. Specifications, plans, and forms of tender may be obtained on application to Mr. J. H. Rider, M.I.E.E., borough electrical engineer, Town Hall, Bolton. Tenders, endorsed "Switchboards," must be addressed to Mr. Alderman Miles, chairman of the above committee, at the Gas Offices, Bolton, not later than November 18.

Lancaster.—The Electric Lighting Committee of the borough of Lancaster invite tenders for the brickwork, boiler seats, etc., required in the fixing of two Lancashire boilers and one set of Green's economisers at the electricity works, Morton street yard. Plans and specifications may be seen, and bills of quantities and forms of tender obtained on application at the office of Mr. John Cook, A.M.I.C.E., borough surveyor, Town Hall, Lancaster. Sealed tenders, endorsed "Setting Boilers," to be sent in not later than 9 a.m. on Monday, the 23rd inst.

Navigation and Electric Launches.—At Kingston on Thames, Mr. John Hill, of the General Electric Power and Traction Company, Limited, Platt's Eyot, Hampton, was summoned for having, on July 15, navigated the electric launch "Fasshild," off Platt's Eyot, on the Thames, on the occasion of Molesey Amateur Regatta, so as to obstruct and impede and interfere with a certain pair-oared race, contrary to the by-laws of the Thames Conservancy. The magistrates having heard the evidence, fined the defendant 5s., and ordered him to pay costs amounting to £2 0s. 6d.

Bournemouth.—The town clerk reported at a meeting last week that the Board of Trade had consented to entertain the application of the Council for a license, and that the formal application and deposits had been made, and the license might be expected to be issued in from three to four months time. At the same meeting the surveyor presented to the Parks Committee a report estimating the cost of illuminating the proposed fountains in the gardens by electricity at £204 9s. each. The scheme was referred back to the committee. Application is to be made to the Local Government Board for sanction to borrow £250 to defray the cost of providing means of communication between the members of the fire brigade and the fire station.

Leamington.—The Telephone Sub-Committee reported at a meeting last week that they had considered the question of providing telephonic communication between the various Corporation offices in the borough, and had had an interview with the manager of the National Telephone Company, who attended their meeting, and stated that the Corporation were entirely clear of his company, inasmuch as no agreement had been entered into, but that he was prepared to reopen the question if desired. The sub-committee have instructed the town clerk to ascertain the cost for the Council to have the telephone plant, etc., in their own hands, so that it shall belong exclusively to the Corporation. The Council have agreed to this.

Southend.—The minutes of the Highways Committee of the Town Council of the 14th ult. contained a note to the effect that the town clerk be instructed to reply to a letter from Messrs. Crompton and Co., enquiring whether the Corporation would consider a proposal for lighting some of the principal streets with arc lamps from the existing electric plant at the pier. The Town Council have empowered the Highways Committee to invite, by advertisement, offers to undertake and carry out the powers vested in the Corporation under the Southend Electric Lighting Order, 1891, special regard being had to the system of lighting, the maximum charges to consumers, and the time for which any contract for the purpose or deed of transfer should run.

Tenders for Wiring.—The chairman and board of management of the Midland Deaf and Dumb Institution, Friargate, Derby, invite tenders for the wiring, provision and fixing of the electric light fittings, the alterations to existing gas fittings where required, and the accessories of the whole or any of these for the electric lighting of the institution. Copy of the specification and form of tender may be obtained on and after the 23rd inst. from Messrs. Bramwell and Harris, of 5, Great George street, Westminster, S.W., or from Mr. J. E. Stewart, the resident engineer, at the Corporation Electric Lighting Station, Silk Mill-lane, Derby. Tenders to be addressed to the chairman of the board of management, and delivered at the above institution on Monday, the 6th November. Full particulars are given in our advertising columns.

Lighting Rubber Works.—The Para rubber works of Messrs. J. E. Hopkinson and Co., at West Drayton, have been lighted by electricity by Messrs. Cathcart, Peto, and Radford. The current is generated by a dynamo driven by a small Tangye's steam engine. The dynamo is capable of supplying current to 80 or 90

16-c.p. lamps at a pressure of 100 volts. From the switchboard three lighting circuits run to feed the lights—two to the factory, and one to the offices, engineering, and packing rooms. The fittings used in the factory are of two kinds, the majority being plain pendants. The other style of fittings used is one made especially by Messrs. Cathcart, Peto, and Radford for use in mill-lighting. The number of lights in the factory offices and out-buildings is close on a hundred. Accumulators are used in conjunction with the dynamo.

Lanark.—At a meeting last week of the County Council, the clerk laid before the meeting a communication from the Caledonian Electric Supply Company, Limited, intimating that they intended to apply to the Board of Trade for a provisional order to authorise them to supply electricity for all purposes within the district and area comprised in the parish of Blantyre, and asking the consent of the County Council. It was agreed that in the absence of information and in view of the fact that when asked for it had not been given, the Council resolved to decline to grant consent. The Council appointed a committee to consider and report upon the present telephone system, and the best means of securing an efficient and economical telephonic service for the benefit of the public and for the administrative departments of the county, and of protecting the community against the disadvantages of monopoly, with power to confer with other local authorities on the subject.

Birkenhead.—Several months ago the Town Council adopted a resolution in favour of carrying out the provisions of the electric lighting order, and a sub committee was appointed to consider the best means of laying down a system of electric lighting. This committee engaged Mr. Shoolbred and Dr. Hopkinson (London) to report on the best means of lighting the town. These experts have now presented their reports, in which they state that they consider no great difficulty would be met in doing the work efficiently, but owing to the straggling character of the district the cost would be considerable, and this is variously estimated at from £15,000 to £40,000. The sub committee now think it advisable to interview Mr. Shoolbred and Dr. Hopkinson personally, but by many members of the Corporation the question is being raised as to whether it would not for the present be advisable to let the matter rest, or, on the other hand, permit a private company to undertake the work.

Weston-super-Mare.—At a committee meeting of the Town Commissioners on the 3rd inst., Mr. Hammond attended and fully explained the advantages to be derived from electricity for lighting the town and other purposes. The committee adjourned the subject for further consideration. A letter was read at a meeting of the Commissioners last week from Messrs. Herbert and Small, electrical engineers, of Bristol, giving gratuitous information in case the Board should decide to hand over their right to a private company. Mr. Phillips thought the question of electrical lighting for the town should be seriously taken in hand. He would propose that a special meeting of the whole Board be held at an early date in order that financial matters in connection with the proposed scheme might be discussed. Mr. Pethick thought it was the duty of the sub-committee to examine and report as to the financial question. He thought it would be much better for such a course to be adopted than to refer the matter to the whole Board. The Chairman pointed out that most of the members were on the Finance Committee. Mr. Phillips then withdrew his proposition, and it was accordingly decided that the matter should be considered at an early date by the committee.

Plymouth.—The Works Committee of the Town Council recommended last week that application be made and all necessary proceedings taken in the next session of Parliament to obtain powers authorising the Corporation to supply electricity within the borough of Plymouth. Mr. Jinkins having moved the adoption of the report, Mr. Bazley asked for further information as to the proposal to obtain powers to supply electricity within the borough. Mr. Keswill said the Electric Lighting Bill would only cost them about £100, and it would protect them against outsiders. They might require electricity in connection with their tramways. He hoped the Council would pass the resolution so that they might be put on an equality with other and smaller towns which had obtained the same powers. Mr. Bond said they were hopeful that at some time they would be able to provide their own power for electric lighting in connection with the water supply as suggested in the report of the water engineer. The Water Committee would support them in what was suggested with regard to electric lighting. Mr. Pethick agreed that the town should be, if possible, lighted by electricity; and the sooner it was done the better. They had abundance of water to provide the electricity, or for any other purpose. The report was adopted.

Brazilian Submarine Telegraph.—The ordinary general meeting of this Company was held on Wednesday at Winchester House. Sir John Pender, who presided, remarked that the receipts for the half year had been £106,860, or a decrease of £7,032 compared with those for the previous half-year, although the diminution of their income had been only £5,010. In the half year under review they had carried about 3,500 more messages with South America than in the previous six months, although they had received £7,920 less. This was owing to a reduction in the tariff of charges from April 1 last, and to a further reduction in the exchange value of the Brazilian silver currency, the value of the milreis having averaged in the half year 12¼d. as against 13¾d. in the previous half year. The total expenditure for the six months had been £40,580, or £16,014 more. This was a large increase, but it had arisen from an exceptional state of things. In the present half year, which was now more than half expired, they had had no expenditure on repairs, and he hoped that they would be able to go on for some time without incurring any further outlay. Notwithstanding the large expenditure referred to, they were able to pay the same dividend, although they were not adding to the reserve fund to the same extent that they had hitherto done. He concluded by moving the adoption of the report, which was carried.

York.—The Streets and Buildings Committee of the Corporation have visited Scarborough, at the invitation of the Hon. C. A. Parsons, for the purpose of inspecting the installation of the electric light by Messrs. Parsons and Co., of Newcastle, for the Scarborough Electric Supply Company. The system adopted at Scarborough is one of the six which have been selected out of a number of others by the York Corporation. The members of the committee were met by the Hon. Chas. Parsons, Mr. A. A. C. Swinton (managing director), and Mr. G. S. Peck (resident engineer). The deputation was first shown a transformer sub station, a number of which are placed at convenient intervals throughout the town. The committee also viewed one of the junction boxes, which are placed at distances of about 50 to 70 yards apart. They were then driven to the station on the Seamer road. The plant here is so arranged as to be interchangeable, the two steam turbine alternators being capable of running jointly 10,000 8-c.p. incandescent lamps. The committee then proceeded through the town and inspected the various shops where the company have made installations of the electric light. At night the deputation and several directors of the local company, including the Mayor (Mr. John Dale), Mr. G. L. Beeforth, Mr. G. Alderson Smith, and Mr. J. Hall, were entertained to dinner by the Hon. C. A. Parsons at the Grand Hotel, the ex mayor (Lieut. Colonel Steble) presiding.

Bristol.—Mr. C. Wills presided over the proceedings of the Electrical Committee of the Town Council on Friday of last week. Over 40 applications were received for the appointment of assistant engineer, and Mr. Hanson, now engaged in electrical works at Newcastle on Tyne, was selected for the post. Several applications for light at short distances beyond the area were considered and it was agreed to supply the Cathedral, St. John's Church (City), and Broadmead Baptist Chapel, on the applicants giving the usual guarantee. Some delay has arisen over the street-lighting, on account of the lamps not being ready. Some discussion took place with reference to questions that were asked at the last meeting of the Council, and the engineer (Mr. Kapp) explained that it was customary and prudent to lay down only sufficient plant for the area determined upon, and then, if extensions were resolved on, to provide further machinery, etc. The committee talked for a considerable time about allowing engineering pupils or improvers to be taken at the works. A majority of the committee were against the engineer taking improvers at premiums as a sort of perquisite. A resolution was proposed that the engineer should be allowed to take improvers, but it was rejected by five votes to three. Mr. Pearson gave notice of his intention to move that improvers should be taken without premium for two years, the Corporation getting the benefit of their services in return for the experience offered.

Windsor.—At a meeting of the Town Council, Councillor Dyson had given notice of motion "That this Council request the Board of Trade to revoke the provisional order granted to the Windsor and District Electric Lighting Company; that the Council do apply to the Board of Trade for a provisional order for Windsor and Eton; and that a committee be formed, to be called the Electric Lighting Committee, to consider the whole question and to report from time to time to the Council on the subject." Arising when the time for the matter to be brought forward arrived, Councillor Dyson said at a meeting last week that since he gave notice certain questions had sprung up which seemed to alter the phase of the whole thing, and though he did not at all desire to do anything or say anything but what would lead the Council to suppose that he believed that for the order to be revoked would be the best proceeding, owing to what had arisen since he gave notice, he felt he should only be doing his duty to those gentlemen who were interested in the late company when he asked permission for the motion to stand over. If anything had been done by the Council it would have to be done before November; but he did not wish in any way to force the gentlemen who were grappling with the late company. The clerk asked whether Councillor Dyson would withdraw altogether, or only till the next meeting of the Council. Councillor Dyson said he would give notice if he intended to bring the motion forward again.

Halifax.—The scheme of the Town Council for expending £30,000 on electric lighting has been approved by the Board of Trade. Since the application was made, the Halifax Mutual Electric Light and Power Company, who have met the requirements of the town for several years, have announced that they will discontinue the supply of light on November 18 next. At a meeting last week of the consumers of the light, presided over by Mr. Needham, president of the Halifax Drapers' and Hosiers' Association, several speakers stated that serious inconvenience would be caused by the withdrawal of the light, especially at this period of the year. Subsequently a deputation waited on the Electric Light Committee of the Corporation, and urged them to arrange with the company for the light to be continued until the Corporation were in a position to supply it themselves. The committee stated that as yet they had been unable to make any arrangement for the temporary supply of the light, but promised further consideration of the matter. The committee have fixed upon a site for the electric station in Multure Hall road, a vacant plot of land owned by the Great Northern and Lancashire and Yorkshire Railway Companies. Negotiations are pending for the acquisition of the site, and as soon as these are completed building operations will be commenced. A letter has been sent to the Halifax Corporation by Mr. T. England, solicitor, on behalf of

the Halifax Mutual Electric Light and Power Company, stating that the company would, in consideration of the Corporation paying them £2,000, guarantee to continue the light for 12 months; or, as an alternative offer, that the company would accept £4,000 for the plant, the Corporation taking over the same at once. A sub-committee appointed by the Gasworks Committee to consider the offers has recommended that neither be accepted. The offer of Mr. W. H. D. Horsfall, architect, to prepare plans, etc., for the proposed electric light works has been accepted.

Fleetwood. The Highway, Lighting, Fire Brigade, and Building Committee recommended, on the 22nd ult., that the proposed electric lighting station should be erected in the town's yard, London-street, subject to the plans and details being afterwards agreed upon; that the present street lamps be used as far as possible for electric lighting, and that the requisite alterations to the lamps be included in any scheme which may be submitted to the Board; that in the opinion of this committee the low-tension system, with accumulators, should form part of any electric lighting scheme for this district, and that the motive power for working the scheme should be obtained by means of producer gas, working suitable gas-engines; that the correspondence now produced and read from Mr. J. A. McMullen be received, and that Mr. McMullen be invited to meet this committee on an early date, on terms now named, for consultation upon the question of electric lighting in this district. The Clerk of the Improvement Commissioners read a letter at a meeting last week from the Board of Trade saying that they had deferred the consideration of the question of the revocation of the order for a further period of six months. Mr. Hudson, of the Electric Lighting Committee, reported concerning the position of the electric light question. No doubt the public were anxious the work should be pushed on, but the installation of the electric light, costing as it would do several thousand pounds, must not be undertaken until it was proved they had a scheme that would be a benefit to the town and a source of revenue. The committee had now formed an idea of what was wanted for Fleetwood. The chairman said it would be satisfactory to the Board to know the public were working hard. In reply to Mr. Shuttleworth, Mr. Hudson said the engineer was favourable to gas as a motive power. It was understood that a meeting of ratepayers would be held before deciding on the question. Mr. Crosby said he should have moved there be a public meeting.

Glasgow. Some eight months have passed since Lord Provost Bell formally opened the central electric station and switched on the street lamps, and already it has been found necessary to make a new departure in regard to the method of supply. The station which the Corporation erected in Waterloo-street to meet the wants of the central area of the city was equipped at the outset with machinery which it was thought would suffice for several years at least. It consisted of seven of Willans's central valve compound engines—two of 80 h.p., two of 150 h.p., and three of 250 h.p.—and an equal number of dynamos, two having an output of 400 amperes at 120 volts, two an output of 400 amperes at 230 volts, and three an output of 670 amperes at 230 volts. The applications for light for private premises have been so numerous that at present two new engines of about 350 i.h.p. each are being put down to light an equivalent of 1,400 8-c.p. incandescent lamps. Beyond this plant, the station contains four dynamos for the arc lamps with which the streets are illuminated. The station was originally designed to supply 22,000 incandescent lamps. The new machinery, however, will increase the number to no fewer than 40,000. Beginning with 60 customers, the officials have had continuous demands made on them, until at present the applications have reached the large number of 268. They have come from all classes of consumers—from wholesale warehousemen, retail shopkeepers, photographers, banks, public institutions, and from the post office, while the Corporation themselves take a very large supply; and as showing the general satisfaction which is experienced, it may be stated that in no instance has a customer wished to have the light withdrawn. Among the customers are many small consumers occupying offices. The current is used for the most part for lighting purposes, but in several cases it is being employed to drive motors and ventilating fans. The municipal buildings take the largest supply yet sent out, the lamps there being equivalent to 1,500 of 8 c.p. In the post office there are 1,000. The Theatre Royal has 1,160, the Clydesdale Bank 900, the Union Bank 744, the Central Agency, Bothwell-street, 700, the Young Men's Christian Association 540, the Windsor Hotel 390, and the Grand Hotel 294. To the Polytechnic warehouse in Argyll-street a supply is sent equivalent to 570 lamps. Messrs. Daly and Co., warehousemen, Trongate, have a supply equal to 520 lamps; and Lafayette, the photographer, a supply equal to 400 lamps. As matters are at present, the station cannot give any more light to private consumers, and in the meantime it has been decided not to consider any new applications. The station, in fact, has reached the limit of its load. As to the policy which the committee may ultimately adopt, nothing has yet been definitely decided. At present a sum of £3,000 is being expended in laying down three feeder mains for private supply. These consist of copper strip, of which no less than 94 tons is now laid below the pavements. Workmen are now engaged in rearranging the machinery in the station. To make room for the two new engines which are being brought in, two of Easton and Anderson's compound marine type of engine, each of 100 h.p., which were put down to drive the dynamos for the arc lighting of the streets, are being disposed of, and the dynamos are being taken to the premises in John-street which the Corporation acquired from Messrs. Muir, Mavor, and Coulson, Limited, when they resolved to undertake the supply of electric light. Shortly after the opening of the Waterloo-street station these premises were closed. Fortunately they were not dismantled, for it is now intended to generate there all the electricity required for the lighting of the streets. The old machinery, consisting as it does of two tandem compound engines, each of 200 h.p., is quite sufficient for the purpose, as will be readily understood when it is mentioned that at present there are only 78 arc lamps in operation. While it is the case that all the available space in the Waterloo-street station is being gradually utilised, some time will elapse before it is fully occupied, there yet being room for four other engines of the size of those now being placed in position. With the approaching completion of the operations of the Central Railway Company, the work of lighting Argyll-street is being proceeded with. The necessary conductors have been laid from Bishop-street, Anderston, to the Cross, and the lamps will shortly be erected, with the exception of a few between Union-street and Queen-street, where the construction of the railway is still proceeding. The amount of money expended up to this point on electric lighting is about £100,000. The price of current to consumers per Board of Trade unit is 7d.

The Leeds Tramways.—The Highways Committee of the Leeds Corporation have inspected the South Staffordshire electrical overhead tramway system. The visit was an important stage in the enquiry at present being made by the committee for the purpose of arriving at a determination as to the future system of tramway traction which shall be adopted in Leeds. One of the features of the South Staffordshire system which has attracted towards it the attention of the Leeds Tramways Committee is that the objection of the overhead wires is here modified by the adoption of only one line of posts, instead of two, as in the case of the Thomson-Houston system on Roundhay-road. The deputation, which consisted of nearly all the members of the Highways Committee, left Leeds by a special train on Friday, and arrived in Birmingham about seven o'clock, and went to the Grand Hotel, where they stayed the night. After dinner, the evening was spent in a long discussion. The committee was supplied with a compendious statement—prepared by the clerk (Mr. John Harrison)—on the observations of the system they had come to inspect, made during a previous visit by a smaller deputation, consisting of four members. The town clerk's notes on the system contain the following remarks: The system was selected after carefully inspecting and considering that of the Thomson-Houston Company. The cars do not run so steadily as those in Leeds, the principal reason for which is, it is suggested, that the vehicles are four-wheeled, and were built originally for steam power. The lines were also originally laid for steam cars by the South Staffordshire Company, and not by the local authority. The cost of laying the lines, it is further stated, was put down at £7,000 per mile. The Roundhay-road line cost £4,372 per mile. At Walsall the original promoter got £20,000 for his concession. This is stated to be about 4d. per car mile, as against 8d. per car mile for steam. If the cost of working were the same as steam (whereas it is only half), electricity would be much more profitable, being more popular, and, therefore, more largely used. The stationmaster at Birmingham confirms this statement, averring that since the electric tram lines have been down they have had a greatly increased railway traffic. The posts are about 60 yards apart, and may be and are intended to be utilised for lamps, either gas or electric. In that case a double set of machinery will be necessary—all duplicated, in fact, except labour—beginning with the dynamos. Exchange engines will become necessary—that is, such as may be used for either traction or lighting. The tramways company use the earth return, and say they have no difficulties. If they existed, however, they might be met by the telephones having metallic returns. The men employed by the tramways company average about 11 hours a day and six days a week. Cars run from 7 a.m. to 11 p.m. It has been suggested that this system cannot be applied to Leeds because of the greater width of the streets; also that it has not had a fair winter's trial at Darlaston and Walsall, having only been working since last January; and, further, that it is a dangerous system, and that frequent accidents happen in connection with it. Upon those points it was for the committee on Saturday to satisfy themselves. Appended to the notes is an account of interviews he had with Mr. Sellon and Mr. Hammond. Mr. Sellon is strongly in favour of the conduit system, by which the wires are underground instead of overhead. He assured the town clerk that the conduit system will succeed against all others. This system is now at work at Budapest, and is about to be put down in Madras. He also stated that he was himself aware that an improved and perfect conduit system now exists. There are several objections to the conduit system, says the town clerk, which may not, however, be insuperable: 1. In regard to cost. The conduits will cost £2,000 per mile more than the overhead system. It might be possible, however, in Leeds to have a portion of the system conduit and the remaining part overhead, as it would be quite practicable for one dynamo to work both conduit and overhead systems. In this case some three miles of the centre of the city might be worked on the conduit system and the outer parts on the overhead principle. It was for the committee to consider whether an outlay of £6,000 would not be justified for the purpose of having the conduit system instead of the overhead system in operation in the heart of the city. 2. The width of the conduit, or slot, is another objection. This in Budapest is 1½in., being of sufficient width to admit of the perfect insulation of two wires. Under the new clause, as settled by the Joint Committee of Parliament, Mr. Sellon states that one wire only will be necessary, inasmuch as the telephones must use the metallic return instead of the tramways, and he affirms that in this case the width of the slot could be reduced to that of the cable system at Birmingham. 3. Another difficulty in connection with the conduit system is the disconnec-

tions at the points and crossings, which in Budapest have given great trouble and annoyance. Mr. Sellon states, however, that this difficulty may be and has, in fact, been overcome. The town clerk remembers that whilst the telephone v. tramway case was being heard before the Joint Committee it was also mentioned, as another objection to the conduit system, that rain or snow caused disconnections. This subject, however, was not discussed by him with Mr. Sellon. Mr. Hammond informed the town clerk that he had now given up contracting, and devotes himself entirely to advising corporations and public bodies on electrical matters. He would be glad to advise to advise the Corporation of Leeds if the services of an electrical expert should be required. On Saturday morning the committee went to Darlaston, where they were met by Mr. Alfred Dickinson, manager of the South Staffordshire Company, under whose guidance they went in a special car to the generating station. One favourable circumstance that was reported to the committee was that there had been no accidents, and that there had been far fewer complaints than in the case of steam tramways. The arms of the poles vary from 3ft. to 13ft., and it was stated that they could be extended to 15ft., which would be large enough for any of the streets of Leeds. In discussing the conduit system, the case of Blackpool was mentioned, but that, it was pointed out, was a mere plaything. Mr. Sellon, when pressed to instance a practical proof of the efficiency of the conduit system, cited that in operation in Budapest, and another about to be laid down in Madras. When the inspection was concluded, the party returned to Birmingham. After luncheon, at which they were joined by Mr. Dickinson and Mr. Sellon, they left the Midland capital for Leeds, arriving in the city about six o'clock. No decision or formal expression of opinion on the merits of the system they had inspected was made; but it is probable that a special meeting of the committee will be shortly held to consider the whole question.

PROVISIONAL PATENTS, 1893.

OCTOBER 9.

18880. **Improvements in automatic electric intermittent motors for driving the mechanism of recording instruments and the like.** George William Farrall, 34, Ann street, Tettenhall road, Wolverhampton.

18894. **Improvements in standards of E.M.F.** Alexander Muirhead and Joseph Arthur Lovel Dearlove, 124, Chancery lane, London. (Complete specification.)

18911. **Improvements in electrical contact apparatus worked by passage of railway trains.** Edward Tyer, 28, Southampton buildings, Chancery lane, London.

18912. **Electrical apparatus for signalling on railways.** Edward Tyer, 28, Southampton buildings, Chancery lane, London.

OCTOBER 10.

18945. **Improvements in compositions for use in telephonic transmitter circuits and in the process employed in their production.** Alfred George Brookes, 55, Chancery lane, London. (Alfred Collinson Cousens, United States.) (Complete specification.)

18951. **Improvements in electricity meters.** Joseph Edmondson, Penny Bank chambers, Halifax.

18977. **Improvements in regulating the supply of electricity to electric glow lamps.** Thomas Rudworth Sharp, County Chambers, Martineau street, Birmingham.

18986. **Improvements in and relating to electric motors.** William Taylor, 4, Dalton place, Hornsey road, Holloway, London.

18990. **Improvements in the method of and apparatus for electrically heating or working metal.** William Phillips Thompson, 6, Lord street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

19018. **Improvements in a system of electrical transmission.** Job Albert Davis and Robert Ashworth Fowden, Norfolk House, Norfolk street, London.

19024. **Improvements in trolley supports for electric railways.** Johan Martinus Andersen, 2, Lancaster place, London. (Complete specification.)

19044. **Improvements in obtaining synchronous working of two rotating electric motors.** Sydney Pitt, 24, Southampton buildings, Chancery lane, London. (Julius H. West, United States.)

OCTOBER 11.

19079. **Improvements in switches used for the proper control of electric light currents.** George John Parfitt and George John Tom Jelley Parfitt, Electric Light and Power Works, Keynsham, Somerset.

19080. **Registering rifle shots on a target automatically or by electricity.** Alfred Hagger and Samuel Brame, 42, High street, Shrewsbury.

19088. **Improvements in cables for telegraphic and telephonic purposes.** Moritz Immisch, 52, Chancery lane, London.

19094. **An improved shade for oil, gas, electric, or other lights.** James Frederick Hoyne and George Robert Stoddart, 52, Chancery lane, London.

19127. **Improvements in printing telegraph systems.** Samuel Rush Linville and Louis Frederick Hettmansperger, Norfolk House, Norfolk-street, Strand, London. (Complete specification.)

19142. **Improvements in electrical fittings.** Edwin Freund, 122, Trinity road, Upper Tooting, London.

19122. **A duplex electric arc lamp.** Charles Tyringham Praed and William Hopkin Akester, 28, Southampton buildings, Chancery lane, London.

19145. **Improvements in apparatus for the electrolytical decomposition of brine and other liquids.** Herbert Guthrie and Malcolm Guthrie, 46, Lincoln's-inn fields, London.

OCTOBER 12.

19146. **Improvements in or relating to telephone book holders or the like.** John Francis O'Brien, 6, Lord street, Liverpool.

19152. **Mercurial voltmeter.** Reginald Beavan, Harberton, Silverdale, Sydenham.

19183. **Improvements relating to the transmission of signals through submarine and like cables, and apparatus for effecting the same.** Alexander Muir, 124, Chancery lane, London.

OCTOBER 13.

19250. **An improved method and means for slaughtering or killing all kinds of cattle scientifically by electricity.** Edwin Marsh, 13, Edward street, Leeds.

19251. **An electric indicator for use in colliery-engine houses and railway-signal cabins.** Charles Brooke Crawshaw and James Battye, Rufford Lodge, Oxford road, Dewsbury.

19283. **An electric heater.** Edward Carstensen de Segundo and Walter Durham, 28, Southampton buildings, Chancery lane, London. (Complete specification.)

OCTOBER 14.

19319. **Improvements in measuring and recording instruments for electric currents.** Jean Grazier and Emile Batault, 45, Southampton buildings, Chancery lane, London.

19363. **Electrical, viz., pneumatical or mechanical apparatus for automatically indicating the names of railway stations or stopping places and to be eventually employed for advertising purposes and indicating the time.** Alexander Rogalla von Bieberstein and Ernst Frost, Grosvenor Hotel, Victoria Station, London.

SPECIFICATIONS PUBLISHED.

1889.

15230. **Electric batteries.** Vavasour. (Second edition.)

1892.

14124. **Electromotors.** Hurd. (Third edition.)

16046. **Electrolytic decomposition of alkaline salts.** Castner. (Second edition.)

16906. **Audible telegraphs.** Harper.

18919. **Electric motors.** Swinburne.

17491. **Applying electricity to the head.** Stevenson.

19874. **Electric lamps, etc.** Davis and Collins.

20214. **Electrolytical apparatus.** Boult. (Kr[illegible] and another.)

20505. **Alternating current motors.** Wise. (Maschinenfabrik Oerlikon.)

20666. **Electromagnetic alarm.** Rabbidge.

1893.

6241. **Electricity meters.** Duncan.

6517. **Electric currents for heating, etc.** Jenkins.

12291. **Secondary batteries.** Boult. (Woodward.)

12577. **Electric traction.** McGregor.

12806. **Electric lighting.** Thum.

14485. **Electric switches.** Nalder and others.

14516. **Electric furnaces.** Kreinsen.

15343. **Electric lamps.** Oesenberg.

15957. **Electromotors.** La Société Anonyme pour la Transmission de la Force par l'Electricité.

15963. **Electric indicators.** Zeitschel.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.		3
— Pref.	—	2¼
Charing Cross and Strand	—	6
City of London	—	11½
Pref.	—	13
Electric Construction	—	1¼
House to House	5	2¾
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¼
London Electric Supply	5	1
Metropolitan Electric Supply	—	7
National Telephone	5	4¼
St. James', Pref.	—	8½
Swan United	3¾	3¼
Westminster Electric	—	5¼

NOTES.

Aberdeen.—An electric tramway is proposed to be constructed in this town.

The Post Office.—A successor to the late Sir A. S. Blackwood has not yet been appointed.

Brighton—Rottingdean.—The construction of this electric railway will shortly be commenced.

Glasgow.—The directors are considering the method of haulage to be adopted on the Glasgow District Subway.

Long-Distance Telephony.—Telephonic communication is being established between Berlin and Elbing, a distance of 310 miles.

The Telegraph to Gilgit.—The telegraph line from Srinagar to Astor has been completed, and Gilgit is now in telegraphic communication with India.

Civil Engineers.—A recent list of the various classes of members constituting the Institution of Civil Engineers shows a gross total of 6,418, against 6,274 12 months ago.

Carriage-Warming.—An improved system of heating carriages by steam is being adopted on the trains of the Manchester, Sheffield, and Lincolnshire Railway Company.

Midland Counties Engineers.—A special general meeting of the Chesterfield and Midland Counties Institution of Engineers will be held at Chesterfield on the 4th proximo.

Bradford.—The two principal features of the Bradford Corporation accounts for the last financial year are the net loss on the gas and about an equal net gain on the electricity.

Kingston-on-Thames.—The new buildings of the Surrey County Council are lighted by electricity. The inauguration of the central station has been postponed to the 4th prox.

Book Received.—We have received from the W. J. Johnston Company, Limited, 167-176, Times-buildings, New York, a copy of Cox's "Continuous-Current Dynamos and Motors."

Cardiff.—The Public Works Committee of the Town Council have advised the latter to purchase the tramway system, so that the entire streets may be under the control of the Corporation.

"Siemens" Incandescent Lamps.—As mentioned on another page, Messrs. Siemens Bros. and Co. will, on and after November 10, sell "Siemens" incandescent lamps at 1s. 6d. each.

Southampton. — The extensive works which the South-Western Railway Company has decided to undertake in connection with the docks at Southampton will be lighted by electricity.

Theatre-Lighting.—The Paris Opera House presented a pretty spectacle the other day, on the occasion of the entertainment of the Russian naval officers, and when the house was equipped with beautiful electric floral decorations designed by M. G. Trouvé.

Lighting of the City.—The Commissioners of Sewers have decided to have a report prepared by the engineer showing what failures of the public electric lighting have occurred during the past quarter, and on what occasions gas has been used in substitution.

Milan.—An international exhibition is to be held next year in Milan. The offices are at 3, Via Ugo Foscolo, Milan. The tramway on the Thomson-Houston system, referred to in a previous issue, has now been experimentally set in operation from the Via Vincenzo Monti to the Sempione.

Electro-Harmonic Society.—Do not forget that the second smoking concert of the season will take place this (Friday) evening at the St. James's Hall Restaurant, Regent-street, W., beginning at eight o'clock. The interesting programme was given in our last issue.

The Brussels Railway.—As mentioned in a previous issue, the local authorities of Brussels are considering a scheme for promoting rapid transit between the various parts of the city. The syndicate formed to deal with the matter have secured the services of Mr. J. H. Greathead.

Chicago Exhibition Awards.—Additional awards in the department for electricity at the World's Fair have been made by the jury, including six to Germany and one each to Great Britain, Austria, and Russia. The award in the British section was taken by the Epstein Electric Accumulator Company, Limited, for storage batteries.

A Point for Municipalities.—In discussing the subject of haulage on tramways, it should be borne in mind that mechanical traction allows of a higher speed being attained—whether permitted is another matter—than with horses, that the speed with cable cars is limited, and that with electricity any rate of speed within reasonable bounds is practicable, and specially applicable for suburban routes.

Spithead.—In the presence of Major-General Geary, Captain Bale, R.E., and other military experts, the new electric appliances at Noman's Fort, one of the Spithead defences, were successfully tested last week. The powerful search-light and the light around the gun-galleries and magazine were found to act perfectly. The work of fitting the forts has been conducted by submarine sappers from Gosport.

The "Electrical Engineer" Appreciated.—As an illustration of the high appreciation and interest manifested in English electrical journals in the colonies, we may mention that the Railway Institute of New South Wales have bound and placed in the circulating branch the *Electrical Engineer* and the *Electrical Review*. Various other journals are to be sold, not being considered of sufficient value to be retained.

Morley.—The Morley Corporation invite particulars of schemes for the lighting of the Town Hall and the borough generally. A premium of £100 will be awarded to the scheme selected by the Council as the most suitable for the requirements of the borough. Plans and particulars to be sent before 1st December, 1893. A print of the conditions of the competition will be forwarded on application to Mr. R. Borrough Hopkins, the town clerk.

Manchester Tramways. — Mr. Alderman King, addressing the shareholders of the Manchester Carriage and Tramways Company on Tuesday, said that, with regard to the motive power, the directors had seen no reason to make any change. He stated that Manchester did not want the unsightly steam-cars of Bradford and Leeds, and as to electric power, they had no evidence yet it was likely to pay. The directors would, however, seek to pursue a policy which, while safe, was progressive.

A Club-Cafe.—A club-café has been opened at 78, Strand, W.C., the object of the management being to make the establishment a club without a subscription. The Exchange Telegraph Company's tape and column printing-machines are provided, and market quotations and other matters can be seen throughout the day free of expense. In addition to this, telephone and District Messengers' Call Service are at the disposal of users without any charge. The establishment, which is lighted throughout

by electricity, should be inspected, so that an opinion of its advantages may be personally obtained.

Lighting at Manchester.—It appears that the Manchester station has not yet been put in proper working order, several hitches being reported to have occurred which have put users of the light to considerable inconvenience. In several instances the annoyance has been all the greater because the gas fittings had been removed and there was no gas to fall back upon when the other light failed. In one case the failure of the light was due to the careless conduct of two men, who were at once dismissed; and in other cases it was due to slight mishaps such as are incidental to the early stage of a large station. An installation of the electric light at the Reference Library has just been completed, the current being supplied from the Corporation central station.

Train-Lighting.—As mentioned in our last issue, the directors of the London, Brighton, and South Coast Railway have given instructions for the equipment of 10 more trains with the electric light. This will make a total of 40 trains so fitted. The superiority of this method of lighting is very marked, and it affords much satisfaction to those working the traffic. Especially is the benefit felt in busy times and foggy weather, when under ordinary circumstances gas-lighted trains would have to be specially sent to the charging stations or put out of working altogether. It is estimated for the above-mentioned reasons that at least 15 per cent. more work is got out of electrically-lighted trains than with those lighted by gas. This, simply in the construction of, say, 100 trains, would mean a saving of something like £45,000 in first cost—*i.e.*, 85 electrically-lighted trains would do the work of 100 gas-lighted trains.

Brewers' Exhibition.—A large selection of engineers' stores and tools is shown at the Brewers' Exhibition by Messrs. W. H. Willcox and Co., of 34 and 36, Southwark-street, S.E. The company having taken over the Farringdon patent pumps, patent Penberthy injectors and ejectors, also sight-feed lubricators, steam cocks, etc., from Messrs. Pontifex and Wood, Limited, of Shoe-lane, E.C., who have given up this part of their business to Messrs. Willcox, the latter thought it would be the means of bringing these goods before the brewing interest, as they had been large consumers of these articles from Messrs. Pontifex and Wood. This trade is being continued by Messrs. Willcox, who also have on view a selection of engine packings, indiarubber goods, hose, asbestos, etc., also leather belting, cylinder, engine, lard, neatsfoot, dynamo, and other lubricating oils, the usual assortment of sundries, including steam-gauges, sight-drop lubricators, gauge glasses, oil-cans, vices, forges, bellows, bolts, nuts, nails, etc.

The Madras Electric Tramway.—As mentioned in our last issue, work at the site of the generating station has been commenced, and it will be pushed on rapidly. The erection of the buildings has been undertaken by Messrs. T. Jones and Dumphy. The car-sheds will be constructed to hold 30 cars, and admit of extension to accommodate 20 more. The connections with them will be made with the main line on the Poonamallee-road, and the lines in the sheds will be intersected with examination pits to allow workmen to get at the car motors. The engine-room will contain four sets of Tangye's compound coupled non-condensing engines of 180 nominal horse-power each. These will drive four Elwell-Parker dynamos, the output of each of which will be 240 amperes at 500 volts; and there will be two smaller dynamos by the same makers. The boiler-room will be equipped with a battery of six Babcock and Wilcox boilers, a Berryman heater, donkey pumps, filters, and overhead water-tanks. The whole of the premises will be lighted throughout by electricity. The whole structure, when completed, will form one of the interesting features of Madras.

Miners' Electric Hand Lamps.—We have already referred to the Sussmann miner's electric lamp, which has now been described by a Newcastle paper. With regard to the latter description, a correspondent states that the fact has been overlooked, and which is also ignored by many expert people, that a safety lamp has usually to be carried by a breathing machine called man. Continuing, the writer says: "The gases met with in mines are not characterised by any property of rendering themselves perceptible to any of the five human senses; and the combustion carried on in a lamp is generally the only guide by which a man can judge of his own combustion. An electric lamp will give a splendid light while its too confiding owner is being smothered. It will illuminate just as well the bottom of the sea, but affords no 'safety' for a man to carry it there. If appliances were added to an electric lamp so that it would automatically give warning of the presence of either black-damp or fire-damp without requiring the making of any special observation, then we would have a more or less perfect 'safety' lamp. That the ordinary safety lamp causes 'miner's nystagmus' I thought had been disproved by Snell, who, I believe, arrived at the conclusion that the complaint arose from fatigue of the eye muscles induced in those whose occupations allow more or less oblique and upward gaze."

The Electric 'Bus is Coming.—Some of the daily papers have been interviewing an official of the Pioneer Electrical Carriage Company—whose formation we lately chronicled—and upon the somewhat slender basis afforded by such details as the above-mentioned official found it wise to give, a very airy superstructure has been reared. Tramways are to be a thing of the past as soon as the new contrivance comes into general use; and the whole "world of road-locomotion revolutionised and recreated." That, of course, is easily done in an evening newspaper, but on enquiring as to the amount of exaggeration in this report from Mr. Frank King, manager of the Electrical Power Storage Company, we were assured that the task has not been so readily accomplished in practice. However, some progress has undoubtedly been made, and Mr. King himself feels sure of ultimate success, not only in the use of the special form of pneumatic wheel (enlarged upon by the newspaper man in such grandiloquent style), but also in the driving and steering of cabs, omnibuses, and similar vehicles by means of electricity derived from storage batteries. When the matter is fully ripe we shall be able to give our readers the complete particulars; meanwhile it is enough to say that the electric omnibus, though well on the way—perhaps, even half constructed—is not yet finished, and therefore not ready for actual work.

City and Guilds of London Institute.—The annual report of the examinations department of the City and Guilds of London Institute, signed by Mr. G. Matthey, chairman of the committee, and Sir Philip Magnus, superintendent of examinations, which has just been issued, shows a considerable development in the work undertaken by the institute. The work of the department is carried on by 77 acting and 41 consultative examiners, all of whom are experts in their several trades. The examinations embrace all the principal industries of the country, and range from such subjects as electric lighting and alkali manufacture to plumbers' work and dressmaking. The institute is doing important work in endeavouring to raise the standard of teaching in the various trade subjects in

which examinations are held. The practical tests which the candidates are required to pass are carefully arranged with the view to the special branch of the trade in which they are severally engaged, and owing to the numerous sections into which trades are now divided, the organisation of these practical tests is attended with considerable difficulty. Thus, in mechanical engineering a candidate may elect to be examined in the honours grade as a fitter, a turner, a patternmaker, or a draughtsman. The practical tests are always held in connection with the written examination, and in many subjects form a necessary part of the qualification for a certificate.

Shiplighting.—The passenger steamer "Zaire," built by Sir Raylton Dixon and Co. for the Empriza Nacional Steam Navigation Company, of Lisbon, is constructed of steel, and is 350ft. long by 42ft. beam. The vessel is lighted electrically, including the masthead and side lights, the installation having been carried out by Messrs. Paterson and Cooper, under the supervision of Mr. E. G. Tidd, their engineer and manager in Scotland. The plant comprises a Robey vertical inverted cylinder electric light engine capable of developing 35 h.p. with a steam pressure of 80lb. The diameter of cylinder is 9½in. and the stroke 9in. The engine runs at 300 revolutions per minute, and is fitted on the same bed-plate with a new type Phœnix dynamo with the spindle coupled direct to the crankshaft of the engine. This dynamo gives 18,000 watts in the external circuit, and is of an inverted type with wrought-iron magnets and Gramme wound armature. The total number of lamps installed is 315, all of which, with the exception of 22 of 50 c.p. fitted in the engine-room, are of 16 c.p. The installation is divided into six circuits. The fittings in the saloon are somewhat of a new departure, being made of real bronze metal, with rich cut-glass globes, and are expected to wear much better than the plated fittings usually seen in ships' saloons, besides giving a most pleasing effect against the marble decorations. The first-class accommodation has plated fittings, with cut and etched globes, while the second-class has brass fittings with opal globes. All the switches and fuses in these parts are of the tumler type, with covers to match the various fittings. A complete system of electric bells has been fitted throughout the boat.

A Dynamo Fault.—A correspondent of a German mining journal relates a curious story of a Lahmeyer dynamo. It appears that the machine, which had not been in use for some time, was brought into requisition and set to work. Just after starting slight sparking was observed; at the close of a two hours' run the sparking suddenly increased so rapidly as to burst out into a flame, the pressure at the same time falling from 120 to 30 volts. It was at first thought that a short-circuit had taken place on the line, which was 330ft. long, and parallel to which an iron wire was carried for some distance. The line was, however, found in order, and it became necessary to look elsewhere for the fault. After many tests had been made in vain, the dynamo was again started, and after half an hour's run the heavy flamelike sparking was repeated. The insulation between the commutator segments was then scratched out by means of a sharp tool, and the fault was discovered and remedied by turning up the commutator. The cause of the fault was as follows: Owing to the dynamo not having been used for a long time, the insulating material, consisting of pasteboard between the commutator segments, had absorbed moisture from the atmosphere and rendered the narrow surface on the top of the insulation capable of retaining the brass dust thrown off by the brushes. The extraordinarily fine metallic dust was found to be embedded deeply into the surface of the insulation, and so converted it into a conductor. The conductivity was further increased by the fact that on the dynamo being set in operation, the warming of the commutator caused the segments to expand and exercise a strong pressure on the insulation. In this way a short-circuit arose between the individual segments, and this caused the flamelike sparking to take place.

The Reduction in the Price of Lamps.—With regard to the forthcoming expiration of the incandescent lamp patents, a representative of the *Pall Mall Gazette* has had an interview on the subject with Major Flood Page, the deputy-chairman and late general manager of the Edison-Swan Company. Concerning the statement that cheap lamps are coming over in shoals from abroad, the major said that there may be a slight spurt at the first, because, no doubt, some people have been holding back; that the cost of lamps compared with the cost of a central station is extremely small; and that the saving effected by a reduction in the lamps would be still more minute in comparison. Continuing, Major Flood Page said the foreign lamps although cheap, and in some cases fairly efficient as light-givers, are likely to have one serious drawback—they will not last, and the governing principle with users is to renew as seldom as possible. The British public will feel aggrieved if it buys cheap lamps and finds that they will not burn half as long as the old ones. In the West-end, and other parts where houses are shut up half the year, there are lamps which have lasted as long as three years without costing a penny for renewals. With regard to competition, the company will not try to undersell the cheap German lamps that will come over. He is only afraid that they will do more than this, and discredit electric lighting in general; for he believes that all sorts and kinds of refuse lamps, "misfits," as it were, are being collected for our benefit; and there are likely to be accidents in consequence of their use. The repeated tests made with every individual lamp turned out at Ponder's End is one of the chief items of expense in their manufacture, and one which no false economy would lead the company to cut down. It is this which helps to make the English lamp dearer than its foreign rivals, but which has made it at the same time so good. It takes six months to train a skilled hand. "Then we make all our own materials at Ponder's End, including glass and gas. We also control the patent lampholder, which everyone uses, and derive a large revenue from its royalties. We manufacture every kind of fitting and electrolier ourselves, and having so many departments of work can shift our hands about from one to the other as the demand on each varies. In this way we have reduced economy in the manufacture to a fine art, and, what is more important, can turn out our lamps with an equality and evenness which only long experience can give. There was a time when in order to produce 1,000 lamps of the same voltage and illuminating power we had to make 1,500. Now we can ensure 1,000 perfect lamps out of 1,025, or even less. If you consider how delicate the lamp is, and what a difference the slightest flaw or irregularity in the filament will cause, you will agree that this is a wonderful result."

Physiological Effects of High-Frequency Currents.—Writing to the *Lancet* of the 21st inst., in reply to a letter from Mr. Swinton, Mr. Wm. G. Sutherland, M.B.Aberd., says: "Mr. Swinton's letter in the *Lancet* of October 14 seems to throw no further light on this subject. The effects on the body are perhaps not altogether proportional to the magnitude of current passed and the density. In the case of the discharge from a Leyden jar we have a comparatively feeble current oscillating many hundreds of thousands of times per second, and at a potential of some thousands of volts, and yet such a rapidly-

alternating current gives rise to energetic physiological effects. Broadly speaking, an alternating current at ordinary frequencies acts chiefly on the nervous system; a continuous one acts more by chemical means, causing electrolytic decomposition of the contained saline fluids. Dr. F. Peterson, in a report of experiments read before the School of Mines, Columbia College, N.Y., on July 30, 1888, came to the conclusion that rapidity of alternation alone sufficed to make a current more destructive to life, a rapidly-alternating current being more deadly than a continuous one of double the voltage. This, we now learn from the recent experiments of M. Nikola Tesla and M. d'Arsonval, holds good up to a certain point only, and magnitude of current as measured in amperes seems to form the prime factor. Contrary to what obtains in the case of metals, the carbon filament of a lamp decreases in resistance as the temperature rises with an ordinary continuous or direct current. With an alternating current the resistance, on the contrary, increases until with currents rapidly alternating millions of times per second the effective resistance of the carbon filament is enormously increased. Hence, applying Joule's law ($H = C^2 R t$) to high-frequency currents, the resistance is enormous, while the current is proportionally small, and yet the total energy represented in watts consumed by the lamp is the same as it would be with a current of greater magnitude at a lower pressure. The volts are numbered by thousands, while the current is only a few milliamperes; but this only proves that so much energy was employed in bringing a lamp filament to incandescence. Is there evidence to show that this energy actually passes through the tissues of the body? With ordinary frequencies the resistance of the human body to an alternating current is less than to a continuous one of the same voltage—just as, in the case of carbon, as soon as the ordinary frequencies are exceeded the resistance offered to the passage of currents rapidly rises. Prof. Clerk Maxwell asserted, and Lord Rayleigh later on experimentally confirmed, the fact that with currents of high frequencies transmitted along metallic wires self-induction causes the current to glide over the surface of the conductor without penetrating to the interior at all. What obtains for metallic conductors may be equally true as regards the human body. The late Dr. W H. Stone, in the Lumleian Lectures, 1886, compared the human body subjected to alternating currents from an induction coil to a condenser, and asserted that with rapid intermissions it was probable that a current did not fully pass before it was neutralised, in whole or in part, by the succeeding current of opposite sign coming from the opposite direction.

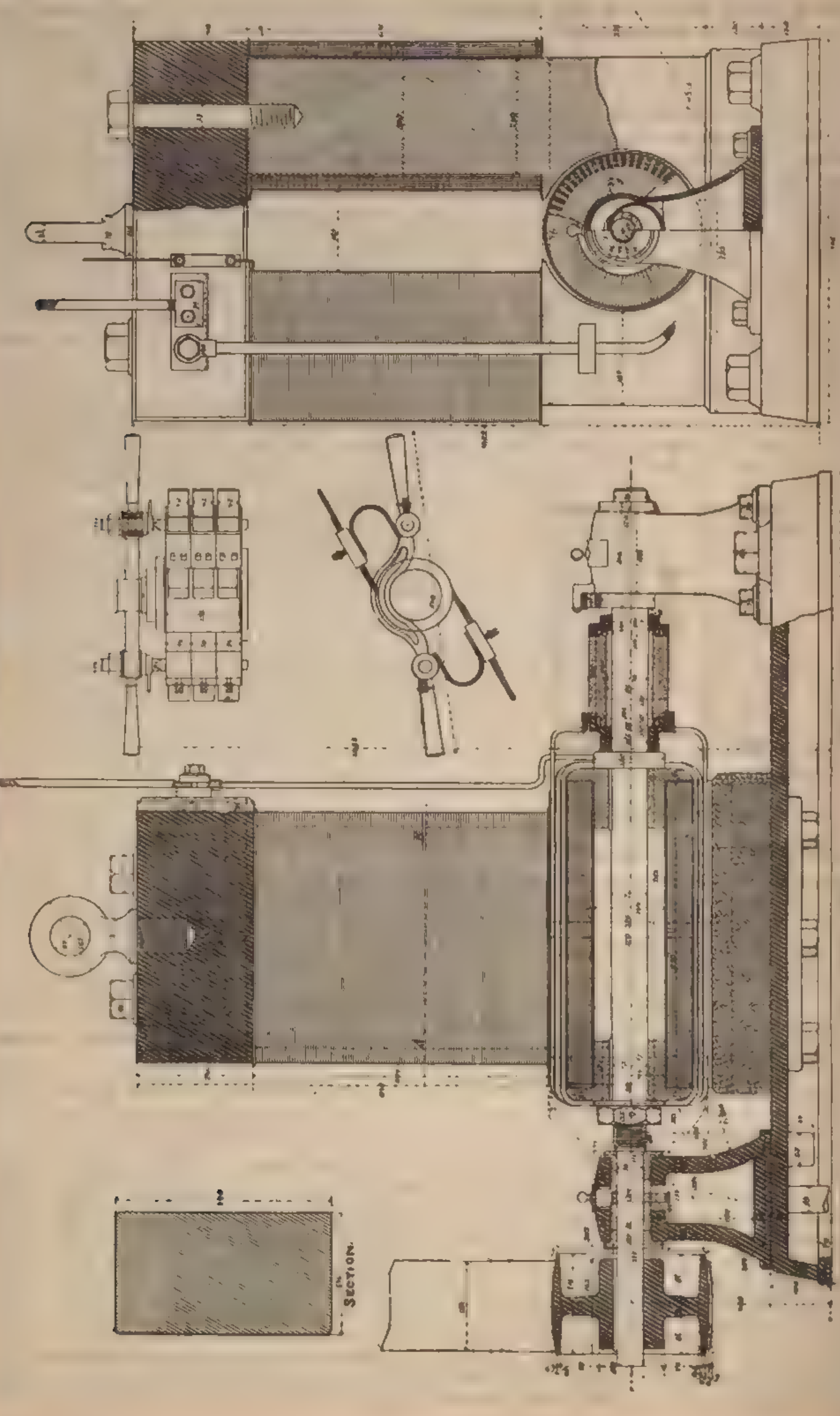
The Braking of Electric Tramcars.—Reference was made in a previous issue to the failures of car brakes on electric tramways in the United States, and now Mr. E. A. Sperry, in the *Electrical Engineer* of New York, deals with the problem of street-car braking. He states that as steam-road practice, road bed, speeds and weights are gradually approached, their experience in the solution of this most important problem should be studied with care. In so doing, however, the features wherein the street-car problem is differentiated from the steam-road problem should be kept prominently in mind. It must be remembered that the locomotive engineer is provided with a complete, expensive, and somewhat intricate apparatus with which to de-energise his train. The periods of its application are comparatively infrequent, and as to personal capabilities he is schooled and trained for years before ever being allowed to touch either the throttle or the triple valve. While working, his pressure gauges allow him to adjust the brake application to a nicety. The time element which is given for the total retardation and final stopping of his train is usually very large as compared with that allowed in street-railway practice. Of the two, the street-railway problem is the most exacting, and in the hands of far more inexperienced operators; and yet we are told that the mechanism involved in its solution must bear only a small ratio to the constantly decreasing cost of the total equipment. Mr. Sperry thinks this is hardly fair. He opines that the purchaser should be willing to spend money to effectually control the retarding car as well as the accelerating car. To be sure, as little expense should be incurred here as possible, but enough to fully meet the requirements. Its importance at once commands the attention of all, and commends the problem as such to the engineer. Considering the inexperience of the operator and the responsibility which at times well nigh overwhelms him, he thinks that, as engineers, we should be willing to set a very high mark to be attained in the ideal brake for electric street-railway service—namely, the use of but a single controlling handle for everything: starting, accelerating, retarding, and braking; the trailer or trailers and all. Let the motorneer have nothing to think of except one handle, and two-thirds of the accidents now occurring will be prevented. Let this handle require no more exertion in its operation than the present controlling handle. Let the motorman fulfil his functions with as little physical exertion as possible; he will have a greater reserve for mental application when necessary. A motorman required to exert an enormous amount of brute force, constantly grinding at the brake, has but little life left to apply in case of emergency. He agrees with a prominent writer of a year or so ago on this subject, where he says that a multiplicity of handles is fatal in time of emergency. Were you ever present at an accident? Mr. Sperry has seen the motorneer unconsciously turn the handle the wrong way when "rattled" and frightened by a terrible exigency in which he suddenly found himself, with consequences that were too horrible to reiterate. The motorneer was blamed. Who would have done better under the circumstances? In the author's judgment that motorneer was not so much to blame; he was handicapped. Many may think the mark that he has herein set is too high for attainment. In his judgment, however, he does not think it is. Of course the problem is a hard one, but almost every attainment of value has been reached along this same route. This emergency is our opportunity. Let us give the struggling street-railway man at once a practical solution of the problem, being satisfied with nothing short of the ideal simplicity named, bringing up thereby the advancement in the brake to the high standard of excellence attained by the application of the power.

Gauging of Alternate-Current Voltmeters.—One is often placed in a difficulty, writes M. E. Meylan in *L'Electricien*, in laboratories or workshops when it is desired to obtain alternating E.M.F.'s and the feeble current necessary in gauging alternating-current voltmeters, or for other purposes. One method, adopted by MM. Hospitalier and Roux in the laboratory of the Ecole de Physique et Chimie, in Paris, consists in driving the alternator by an electric motor energised from a battery. The following method, according to M. Meylan, is very simple, and can be used to great advantage: In a dynamo, or an ordinary continuous-current motor, any one segment of the commutator passes successively over all ranges in the difference of potential comprised between zero (if the machine has one part connected to earth) and the maximum voltage of the machine—say, 100 volts, 150 volts, etc.—and then again pass from zero in one revolution of the machine in the case of a bi-polar dynamo. If, then, any two segments of the commutator are connected to two

insulated rings, it will be possible to obtain an alternative difference of potential at the two brushes, or collect an alternating current, which is produced by the working of the motor. The frequency of this current is equal to the number of revolutions per second. The useful voltage collected at the two brushes depends upon two factors: the relative disposition of the segments of the commutator connected to the rings and the disposition of the magnetic field. By taking two segments diametrically opposite on the commutator the maximum difference of potential is realised. The relation of the alternating voltage to the voltage at the brushes (for a very feeble output) depends upon the form of the magnetic field. The only practical difficulty arises from the fact that it is necessary to obtain extreme angular speeds to reach practical frequencies. In fact, the frequency of 60 (40 is the lowest used in practice) corresponds to a speed of 3,600 revolutions per minute; the frequency of 100, which is largely used in England, is equivalent to 6,000 revolutions, and the frequency of 125, as employed by the Thomson-Houston and Westinghouse people in the United States, corresponds to 7,500 revolutions per minute. These speeds are much higher than one is accustomed to consider in practice, and a special plant is necessary to obtain them. Nevertheless, as the power furnished is very weak, since it only concerns some hundredths of an ampere, it is sufficient to have a small well-constructed dynamo so that there will be no danger. A small Perret motor, used by M. Meylan, ran at 1,600 revolutions, giving 120 volts, and up to ½ h.p. Leaving the exciting out of consideration, it would have been necessary to apply an E.M.F. of from 360 to 400 volts to drive the motor at 5,000 revolutions, but this is not very practical. A liquid rheostat was therefore inserted in the inductive circuit, and this enabled the exciting to be reduced three or four times. Under these circumstances a pressure of 180 volts gave a speed of 5,500 revolutions. By adjusting the rheostat the frequency may be very easily varied, this proving very useful in the investigation of alternating-current voltmeters. It is, of course, necessary to regulate carefully the brushes so as to avoid sparking under these conditions. Thus, with a small motor and a battery of accumulators capable of giving a fraction of an ampere one can produce at will, by a simple manœuvre of the commutator, alternating E.M.F.'s with a feeble output by varying the voltage from a few volts up to 100 or 130 volts with any frequency easy of measurement. On completing the system, by a small transformer one can easily obtain several thousands of volts constant for verifying high-tension electrostatic voltmeters. This arrangement, M. Meylan concludes, is the most practical, and is specially suitable for laboratories and for workshops where measuring instruments are made.

The Proposed Pacific Cable.—The *Times* of Monday states that Mr. Sandford Fleming has left Canada for Australia with the view of submitting four alternative routes for the proposed Pacific cable from Vancouver. Mr. Sandford Fleming's name has been for many years associated with the scheme of connecting the Empire right round the world by a cable of which the landing stations should be everywhere in British hands, and it will be remembered that on behalf of the Colonial Conference of 1887 he won the sympathy of many of his colleagues for the scheme for the construction of a Pacific cable which he laid before them at that time. The Canadian Pacific Railway had then been in existence for about a year, and Mr. Sandford Fleming urged that the creation of this first important link in the chain of British communication through the continent of America was a fact that ought to be utilised in the interests of Imperial unity, by continuing the chain across the Pacific till it touched British territory again upon the further shores. There were, he pointed out, three ways of carrying out this idea, the third being the construction of the Pacific cable from Vancouver, *viâ* Honolulu and Fiji, to Australia. The colonial Governments on either side of the ocean are willing to contribute subsidies towards the construction of the cable, and the supporters of the scheme on the Canadian side look anxiously for the help of the Imperial Government. In despair of obtaining it, some of the Australian Governments have agreed to subsidise the French line, of which the Société des Télégraphes sous Marins (as mentioned in our last issue) has already completed a first section from Queensland to New Caledonia, but the general feeling is that this has been a false step, and is likely to hinder rather than to help the construction of a through British cable. A cable which passes through French stations in the Pacific could not expect to be subsidised for Imperial purposes. It must base its chances of success wholly on the commercial prospect, and if this justifies its construction, the existence of one Pacific cable already monopolising such business as there is will for a long time to come prohibit the creation of a second. The scheme of the French company's cable can only be acceptable to the English communities concerned on the assumption that no British cable is to be hoped for. If a British cable is to be made, it must be made before the French company has decided on the full extension of its lines to the American coast, and until this possibility is definitely rejected the colonies of Victoria, South Australia, and New Zealand join with Canada in withholding their support to the French line. The prospects of cable business depend, of course, to a great extent upon the business done by the shipping lines. What this is likely to be has been made clearer of late by the investigations of the interchangeable commodities of Canada and Australia, made on behalf of the new line of steamers established by Messrs. Huddart and Co. All the information which was required to justify the venture of the ships serves to define the prospects of the cable as far as its purely commercial aspect is concerned. The trade of the four-and-a-half millions of Canada with the three-and-a-half millions of Australia hardly seems at first sight likely to repay the heavy cost of the construction of 6,000 miles of cables. Nor is it, indeed, probable that a cable line could at first exist without large subsidies. But it has to be remembered that telegraphic communication, once established, is not for this generation only. All that can be said on the score of insufficient trade might have been said at the first conception of the other great cables of the world. It is now stated by the supporters of the scheme that the technical difficulties of the course which it is proposed to take are nowhere so great as they have been represented to be, and that the laying of the line offers no special obstacle to the realisation of the project. It is understood that the schemes which Mr. Sandford Fleming is about to lay before the colonial Governments of Australia ask only for a collective subsidy of £60,000. What is now wanted in order that the project may be fairly judged is precisely what it is understood that Mr. Sandford Fleming's mission to Australia is to effect—namely, a clear exposition of some practical scheme for its fulfilment. Mr. Sandford Fleming will have a strong ally in Australia in Mr. Bowell, the Dominion Minister, whose visit will be contemporaneous with his own. Sir Thomas M'Ilwraith, the retiring Premier of Queensland, said the other day that Queensland always favoured the construction of a purely British cable across the Pacific, and would warmly welcome the support of the mother country to such a scheme. We believe this matter is now attracting the attention of the English Government.

DETAILS OF AN EDISON DYNAMO.



The above illustration gives the details of an Edison machine with drum armatures. The measurements are metric. Output, 30 kilowatts at 800 revolutions per minute. The pressure is 125 volts.

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.*

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

XIII.

(Continued from page 239, Vol. XI.)

RESISTANCE, *continued.*

Differential Galvanometer.—This type of instrument is, of course, properly classed, not under the head of resistance but of current measuring instruments, as its function is primarily to compare and measure differences in currents of electricity. Owing, however, to its great adaptability for measuring, or rather comparing resistances, a reference to its adjustment and applications to this special purpose will not be out of place under the heading of resistance-measuring instruments; while the construction of the instrument itself, and its various applications to the measurement and comparison of currents will be given when these types of measuring instruments, known as "electrical balances" (to which class the differential galvanometer really belongs) are being dealt with.

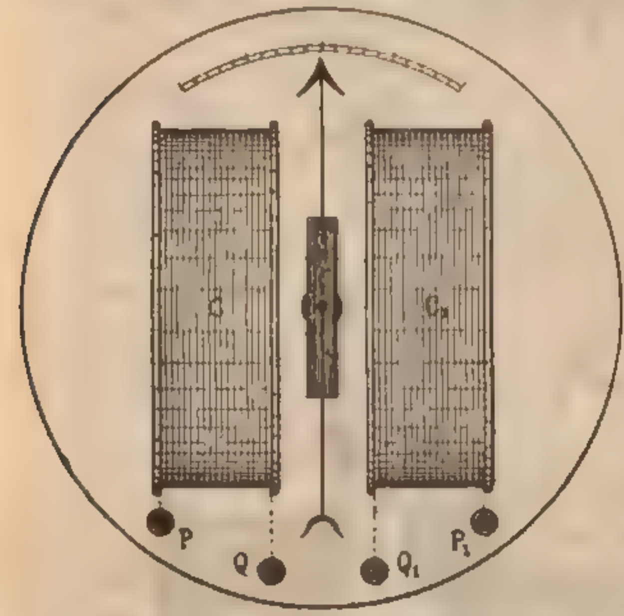


FIG. 33.—Differential Galvanometer—Plan View.

The differential galvanometer, of which the main features are shown in Fig. 33, consists essentially of a magnetic needle freely suspended in the vicinity of two precisely similar coils of wire, C and C_1, so placed that they both influence the needle to an exactly equal extent when the same or equal currents are passing through them. The terminals of the two coils, P & Q and P_1 & Q_1, are so arranged that the coils can be connected up in series or in parallel, or can be entirely disconnected from each other, according to the requirements of the case. The instrument is usually provided with a set of shunts whereby the sensibility of either or both coils can be varied to any desired extent, the usual ratios employed being

$$\frac{1}{10}, \frac{1}{100}, \frac{1}{1{,}000}.$$

Figs. 34 and 35 illustrate diagrammatically two different methods of connecting up the galvanometer coils, battery, contact-maker, known variable resistance, and the unknown resistance. In Fig. 34 the two galvanometer coils, C and C_1, are connected up in parallel, the one coil C_1 being in series with the known variable resistance R_1, while the other coil C is in series with the unknown resistance R. Whenever R_1 has been so adjusted that the galvanometer needle shows no deflection on the circuit being completed by closing the contact-maker K, the currents flowing through the two coils, C and C_1, must be exactly equal, as they are in opposite directions and just neutralise each other's effects on the needle. But if the currents are equal, the total resistances in the two sections of the divided circuit must also be equal to each other, and therefore as the resistance of C is equal to that of C_1 it follows that

$$R = R_1.$$

With the other arrangement, shown in Fig. 35, the two coils, C and C_1, are in series with each other, the battery, the contact-maker, and the two coils all forming one circuit. The known resistance R_1 is connected up as a shunt to C_1, the one coil of the galvanometer, and the unknown resistance R is similarly connected as a shunt to the other coil C. Here, again, when the known variable resistance has been so adjusted that the closing of the circuit causes no deflection of the galvanometer needle, we have an equality between R_1 the known variable resistance, and R the resistance being tested; for in order that precisely equal currents should be passing through C and C_1, they must both be shunted to an exactly equal extent, and therefore we have again

$$R = R_1.$$

When the unknown resistance R is large compared with the resistance of one of the galvanometer coils, the former of the two methods, in which the coils are in parallel, is the most sensitive, and when R is small compared with the resistance of the coil, the second method, in which the coils are in series and shunted by the resistances, will be found preferable.

In order to increase the sensibility and accuracy of the differential galvanometer, it is advisable to make the coils of high resistance, so as to minimise the error due to inequalities of the coils; and in order to make the readings more accurate, the contact-maker K should be a reversing

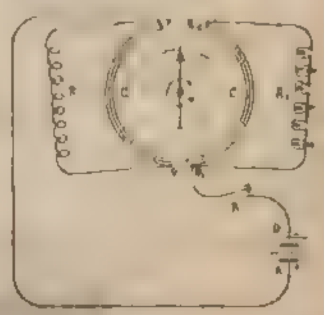


FIG. 34.—Coils in Parallel. FIG. 35.—Coils in Series.
Methods of Connecting up Differential Galvanometer.

one, so that the directions of the currents may be readily reversed through the coils of the instrument, and the mean of the two deflections taken.

(To be continued.)

[* There has been an unavoidable delay in the continuation of these articles owing to the long and serious illness of one of the authors. We trust there may be no further interruption in their publication.—ED. *E. E.*]

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

DISTRIBUTION OF ELECTRIC POWER.

(Continued from page 294.)

TABULATION 30.

Conditions of Supply.		Two-wire.	Three-wire.	Five-wire.
Pressure in volts		100	200	400
Current in amperes		400	200	100
Total section of copper in sq. in.		2·0	1·25	·75
Total weight of copper in tons		2·08	1·30	·78
Percentage of loss of pressure		4·0	2·0	1·0
Percentage of loss of energy		4·0	2·0	1·0
Percentage of copper used		100·0	62·5	37·5
Percentage of copper used	with 4% loss constant	100·0	31·25	18·75
Supply distance in yards	with 4% loss constant	200	[illegible]	800

A summary of the three methods of low-pressure distribution is given above in Tabulation 30, in each case the power received from the generating source being 40,000 watts, none being tapped off along the line, so

that the whole of what is delivered is utilised at the far end, the distance served being 200 yards from the generating source. The last row of figures in the tabulation gives the increased distance the power can be sent, when the percentage of fall of pressure or loss of energy is kept constant.

High Pressure System.—We may now pass on to consider the second general system of distributing electric power—namely, by means of high pressure alternating currents. From the preceding figures it is seen that, generally, the higher the pressure employed the greater in proportion is the distance a given power can be transmitted and distributed, keeping the loss of energy constant; also, that for a given distance and loss of energy the weight of copper required will vary inversely as the square of the pressure employed.

This last law is, however, only theoretical, on account of making the loss constant for each case. The usual pressure used on high-pressure circuits is about 2,000 volts. Suppose we use 20 tons weight of copper to transmit 40 kilowatts a distance of 2,000 yards, with a loss of 40 per cent. or 16,000 watts, when a pressure of 100 volts is used. Then, if we used a high pressure of 2,000 volts, we should only require a current one-twentieth the amount; hence the sectional area, and consequently the weight of the new conductors, need only be one twentieth also—that is, one ton. But the loss of energy on the line is obtained by the expression $C^2 R$, so that although the resistance of the conductors increases while the current decreases, it must be remembered that the loss depends on the square of the current. Comparing the two losses, we have

with 100 volts, $C^2 R = 400^2 \times \cdot 1 = 16{,}000$ watts;
„ 2,000 „ $C^2 R = 20^2 \times 2 = 800$ „

so that the loss in the second case is only one-twentieth of the loss in the former. But the law states that the loss must be constant, so that the resistance of the 2,000 volt circuit must be either increased 20 times, or the resistance of the 100-volt circuit must be decreased 20 times; and this is where the result is absurd in a practical sense, because it would signify in the former a current density of 8,000 amperes per square inch, and in the latter case a density of only 20 amperes; the first would burn up the wires, while the second would be like burying money in the ground. The result, however, would be that the weight of the copper in the 2,000-volt circuit would be still further reduced to one twentieth again, and as it has already been reduced to one-twentieth before on account of the diminished current, this makes, finally, one-twentieth of one-twentieth, or one four-hundredth, so that using 20 tons with 100 volts, we should only require $20 \div 400 = \frac{1}{20}$ of a ton with 2,000 volts, thus exemplifying the theoretical law given above.

Neglecting to keep the loss of energy constant, and, instead, keeping the current density constant, we can then reach a practical solution, and this is, that the weight of copper used is inversely proportional to the pressure used, while at the same time the loss of energy becomes decreased in proportion as the pressure used rises. There is thus a great saving to be effected in the use of high-pressure currents, for not only is the weight of copper decreased, but the loss also. Applying this practical law, we find that the cost with a 100 volt circuit would be, say, $20 \times 60 = £1{,}200$ for copper, whilst with 2,000-volt circuit the cost would be only $1 \times 60 = £60$, and the loss of energy only one-twentieth of the loss in the former instance.

Although these advantages are very great and of a substantial nature, so far as concerns financial matters, it must not be thought that there are no drawbacks to the use of the high pressure system. The greatest of these, and the one most troublesome to deal with, is that of reliable insulation. The greater the pressure at which an electric current is driven along a conductor, the more difficult is it to confine it to the conductor and so prevent leakage. It is comparatively easy to well insulate a cable that is worked at 100 or 200 volts pressure, and the indiarubber covering need only be fairly thin, and hence inexpensive, but when dealing with 2,000 volts, heavy and very expensive covering is absolutely necessary, so that, roughly speaking, a 100-volt main is composed of a thick copper conductor with a thin covering, whilst the 2,000-volt main is a thin wire with a covering composed almost entirely of guttapercha and indiarubber, and having a depth perhaps twice as great as the diameter of the conductor. The cost of a cable is composed of two factors: (1) the cost of the mass of copper therein, (2) the cost of the insulating covering on the copper. In the case of low-pressure distributing cables, it is evident that the cost of copper as compared with the cost of insulation is high, while with high-pressure cables the cost of copper, as compared with that of insulation, is low, so that the ratio between the two varies greatly and inversely. For example, if we transmit 40 kilowatts of electric power at 100 volts one mile, we might use a cable costing £1,800 per mile, while if we transmit the same power at 2,000 volts pressure, we should use a cable which would only cost about £300 per mile. In the latter case the weight of copper is only about one-twentieth the weight used in the former case, and yet the total cost of the latter cable is one-sixth of the former.

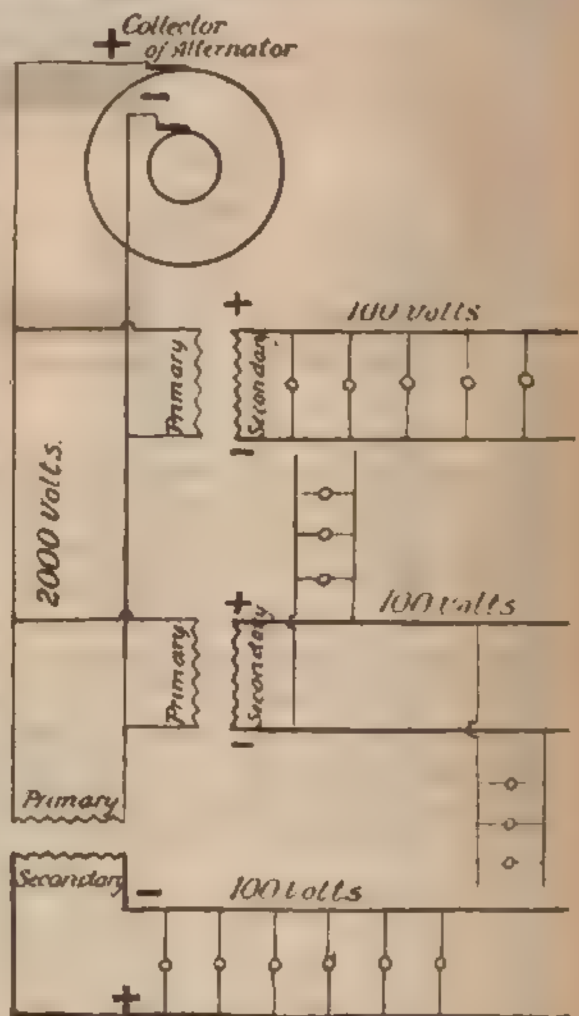


Fig. 31.

Fig. 31 shows how connections are made on a high-pressure alternating-current system. On an alternator, as already explained, there is no commutator, and the two ends of the armature wires are led to two rings, or "collectors," fixed in the armature shaft, each well insulated from the shaft and from each other. A couple of brushes are fixed on each collector, and the two circuit wires are led from the two collectors, as shown in the diagram. One is marked + and the other − in order to distinguish the two, although the polarity of the machine is constantly changing from + to − and back again. The two line wires are of small diameter, but thickly insulated, as only small currents are used. This thin wire and any tappings that may be taken off in parallel is named the "primary" circuit, and the two terminals of the fine wire or primary coil of a transformer are joined up to the primary circuit. This coil is indicated by the thin zigzag lines, the thick zigzag lines drawn opposite it denote the thick or secondary coil of the transformer, and its terminals are therefore connected on to the

thick wires of the secondary circuit, or lamp circuit, from which the lamps are run in the usual parallel way.

The pressure in the primary coil of the transformer is that of the primary circuit namely, 2,000 volts; while the pressure in the secondary coil and secondary circuit is only 100 volts, so that the function of the transformer is to receive a small current of high pressure and to send out a large current of low pressure.

(To be continued.)

DESIGN OF ALTERNATING-CURRENT MOTORS.*

BY EMIL KOLBEN.

There is no essential difference in the design of a single, two, or three phase motor, and, in order to simplify matters, we shall treat the problem for the single-phase motor only, noting, at the same time, the way how to apply the results to the design of motors of the multiphase type. We shall also consider the following typical form only, it being the simplest, the cheapest, and most economical, and therefore of chief commercial interest and value. It consists of two essential parts: 1. The external, stationary, inducing part or "field," A (see Fig. 1), made of a subdivided iron body, with a continuous ring or drum winding embedded in grooves or holes, and wound so as to form two, four, or more poles. 2. The internal rotating induced part, B, the armature, with a winding closed in itself. This latter may be arranged with the bars connected all in multiple arc (Figs. 2 and 3, Dobrowolsky's arrangement), or wound with a number of sections independent of each other (Figs. 4 and 5), each section with a ring or drum winding, made so as to form as many poles as are formed by the external field winding. The first arrangement can be treated as a special case of the second.

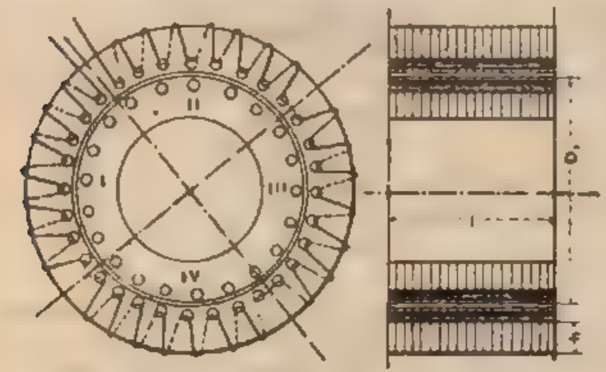
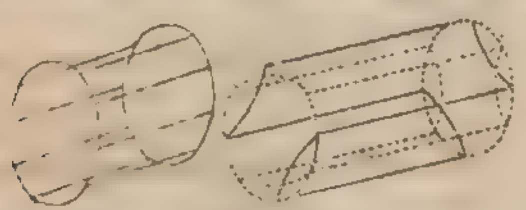


FIG. 1.



FIGS. 2 AND 4.

Let it now be required to design an alternating-current motor of the single-phase type, to deliver a power of P effective mechanical power units (horse power) equal to $W_1 = 736$ P watts at its pulley: Required to find the iron dimensions of the field and the armature, the number of turns, and the sizes of wires of the inducing and the induced circuits at a given impressed E.M.F., and, finally, the efficiency of the motor.

The first point to settle upon is the axle speed of the motor, V. This is determined by the frequency of n periods per second and the number of pairs of field poles, p. From these we find the number of revolutions per minute:

$$V = \frac{60\, n}{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The motor will have very nearly this theoretical speed when it is running free. At full load we shall allow a slip of $\frac{1}{s}$, so that the speed of the motor when it is loaded is $V - \frac{V}{s} = V\left(1 - \frac{1}{s}\right)$. If, for example, the slip is 4 per cent., then $\frac{1}{s} = \frac{1}{25}$, and the full-load speed $\frac{24}{25} \cdot V$. Thus we find a circuit of low frequency of 50 cycles and for one of high frequency of 130 cycles the following theoretical speeds:

Number of poles of motor.	V at 50 cycles (revs. per minute).	V at 130 cycles (revs. per minute).
4	1,500	3,900
6	1,000	2,600
8	750	1,900
10	600	1,560
12	500	1,300
16	375	975
20	300	780

From this simple comparative table we draw at once the important conclusion that the low frequency is preferable for the design, as it permits of reducing the number of

FIG. 3.

poles. At 50 cycles we can limit this number to between four and eight for motors from 1 h.p. to 50 h.p., while we need for the same sizes 10 to 20 poles at the high frequency of 130. We shall see later on that the idle or magnetising current increases directly with the number of poles, and this fact is no doubt one of the main reasons of the difficulty of designing good motors for high-frequency circuits.

I. *Design of the Field.*—The important question to consider is the proportion between iron and copper weight in the field. Similar considerations as in the design of trans-

FIG. 5.

formers may take place. The maximum induction density, B, in the iron is given by the frequency, the permissible loss, and the heat-radiating surface. B will in general be the same as in well-designed transformers, and it is advisable to take the following values:

For 40 cycles	B = 6,500 to 5,500
" 50 "	6,000 to 5,000
" 60 "	5,000 to 4,500
" 80 "	4,500 to 4,000
" 100 "	4,000 to 3,500
" 120 "	3,500 to 3,000

It would not be difficult to find by theoretical investigations the best relation between the weight of iron and copper, but by experience on a large number of designs I found that with the normal values of the induction in the iron an empirical constant can be found, by means of which the number of field turns, N, can be easily chosen.

This constant, C, is the number of ampere-turns per

* From the *Electrical World*, New York.

centimetre circumference of the bore of the field (or of the diameter of the armature, as the two are quite nearly equal). Let D_1 centimetres be the armature diameter [it can be found from the permissible circumferential speed $U_1 = 1{,}500$ to 2,500 centimetres per second, and V by

$$D_1 = \frac{60\ U_1}{\pi\ V}\Big] \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and I the $\sqrt{\text{mean}^2}$ value of the current in amperes at full load; then the constant will be expressed by

$$C = \frac{I\ N}{\pi\ D} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For frequencies of 40 to 80 cycles and an induction density in the air-gap of 2,000 to 3,000 C will vary from 100 to 150. This rule, of course, is but "a rule of thumb," and has to be applied judiciously in each special case From (3) we find the number of field-turns:

$$N = \frac{\pi\ D_1\ C}{I} \quad . \quad . \quad . \quad . \quad . \quad (3^1)$$

In order to determine exactly the full-load current, the exact value of the magnetising or idle current, i, should be known beforehand. A method for calculating this will be given later on. But an approximation sufficiently accurate can after some experience readily be obtained by taking I a certain percentage larger than the true watt current $I = \frac{W_1}{\eta\ E}$, wherein η is the full-load efficiency of the motor, and E volts the $\sqrt{\text{mean}^2}$ value of the impressed E.M.F. of the circuit. Two or three phase motors will have a comparatively larger number of field-turns, as the resultant current of the phases must be taken in consideration. They will consequently be somewhat lighter.

FIGS. 6 AND 7.

The primary or inducing winding must be placed in holes or grooves uniformly all around the circumference, in order to reduce the air-gap reluctance to a minimum. The width of the gap is given by the mechanical consideration of sufficient clearance between rotating and stationary part only, and varies between one and two millimetres from the smallest to the largest sizes.

From the total number of turns, N (or wires, if drum winding is used), the maximum value of the total induction can be calculated after the well-known transformer relation:

$$B\ S = \frac{\sqrt{2}\ .\ E\ .\ 10^8}{2\ \pi\ n\ N} \quad . \quad . \quad . \quad (4)$$

wherein S is the effective cross-section of the iron. B has the values given above for the various frequencies. Of this total induction only a certain percentage will be useful by passing through the armature and inducing in its conductors currents which will produce the required mechanical torque between them and the stationary field. The other portion will form a stray field through direct leakage from pole to pole, chiefly on the external surface of the iron body, Fig. 4. This leakage will increase with the size of the gap, with the induction density in it and in the iron, and also with the number of poles. A ring winding will, of course, produce a larger leakage than a drum winding. The stray field increases with the increasing load, and reaches an enormous amount in starting of the motor, when the ampere-turns on the field are many times larger than at load. At the moment of starting the useful induction is therefore reduced to a minimum, just at the time when a maximum induction is most needed. Another source of leakage is the small iron bridges left between the holes for *the winding, Fig. 5.* By using a half-closed groove, as in *Fig. 6, this leakage can be made negligible.*

The useful total induction, Z, will therefore be expressed by

$$Z = x\ S\ B \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where x is a fraction less than unity. If the motor is running loaded at normal speed, x can vary according to the design from 0·95 to 0·70; the author has found the values by various experiments.

From the effective iron section, S, the iron dimensions, h and l (Fig. 1), are found by

$$S = 0{\cdot}85\ h\ l,$$

by making an allowance of 15 per cent. for the paper insulation between the iron discs. In order to determine the length of the field, l, we chose the maximum induction density, B_1, in the air-gap with the view that the magnetising current will increase in direct proportion with this gap density If the motor is wound for two p poles, then the effective iron surface of one pole will be $\frac{0{\cdot}85\ \pi\ D_1\ l}{2\ p}$ and the useful total flux through one pole:

$$2\ Z = \frac{0{\cdot}85\ \pi\ D_1\ l\ B_1}{2\ p} \quad . \quad . \quad . \quad . \quad (6)$$

From this we find

$$l = \frac{4\ p\ Z}{0{\cdot}85\ \pi\ D_1\ B_1},$$

and by inserting the proper value for Z from equations (4) and (5):

$$l = 0{\cdot}34\ \frac{x\ p\ E\ 10^8}{D_1\ B_1\ n\ N} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and

$$h = 0{\cdot}78\ \frac{B_1\ D_1}{x\ p\ B} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

For 40 to 80 cycles and a small gap B_1 may be taken from 4,000 to 2,500. With these dimensions of the iron body and with the induction densities given, the iron losses by hysteresis and eddy currents in the field can be readily calculated. The total length of the copper winding and its resistance can also be found and the copper loss in the field thus determined.

II. *Design of the Armature.*—The problem of starting shall be considered separately. For the present let us assume that the motor is giving off its normal output of W_1 effective watts causing it to run with a slip of $\frac{1}{s}$ at a speed of $V\left(1 - \frac{1}{s}\right)$. If the motor was running at its theoretical speed then there would be no E.M.F. induced in the armature conductors, as then there would be no difference between the speed of the armature conductors and that of the rotation of the field induction. By virtue of the slip, however, an E.M.F. is induced in the armature conductors producing currents in them whose strength depends upon the value of the slip and the armature resistance, R_1. The mechanical work performed by the motor will depend upon these currents. They will produce in the armature conductors a certain watt loss, w_1, which, together with the slip, is at the same time a direct measure for the useful work performed by the motor.

Suppose the armature is wound in u sections of m conductors each, these m conductors being connected in series; each of the sections to be short-circuited in itself, independently of the rest. Let r_1 be the resistance of one conductor (including the connecting wires) and $R_1 = m\ r_1$, the total resistance of one section. At an induction density, B_1, produced by the field, Fig. 6, at the slip $\frac{1}{s}$ and a circumferential speed $U_1 = \frac{\pi\ D_1\ V\left(1 - \frac{1}{s}\right)}{60}$ the E.M.F. induced in m armature conductors connected in series each of the induced length l (Fig. 1), will be:

$$E_1 = \frac{m\ l\ B_1\ U_1}{10^8\ s} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

The copper loss in all u sections of the armature is thus

$$w_1 = u\ \frac{E_1^2}{R_1} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

As the motor runs with the slip $\frac{1}{s}$ against the load, the total watts delivered by the motor must be s times as large as armature loss—viz.:

$$W = \frac{E_1^2}{R_1} u s,$$

and as $W = W_1 + w_1$, we find the useful mechanical energy delivered at the motor pulley:

$$W_1 = \frac{E_1^2}{R_1} u (s - 1) \quad . \quad . \quad . \quad . \quad (11)$$

By inserting the proper value of E_1 from (9) in (11) and considering that $m u = N_1$, which is the total number of conductors all around the armature, we find the important equation for the useful motor output:

$$W_1 = \frac{N_1^2 l^2 B_1^2 U_1^2}{10^{16} u R_1} \frac{(s - 1)}{s^2} \quad . \quad . \quad . \quad (12)$$

and from this the resistance of one armature section:

$$R_1 = \frac{N_1^2 l^2 \bar{B}_1^2 U_1^2}{10^{16} u W_1} \frac{(s - 1)}{s^2} \quad . \quad . \quad . \quad (13)$$

The $\sqrt{\text{mean}^2}$ current in the armature conductors in amperes

$$I_1 = \frac{E_1}{R_1} = \frac{m l B_1 U_1}{10^8 R_1 s} \quad . \quad . \quad . \quad . \quad (14)$$

or expressed directly by the useful watt output:

$$\bar{I}_1 = \frac{10^9 W_1}{U_1 N_1 l B_1} \frac{s}{s - 1} \quad . \quad . \quad . \quad . \quad (15)$$

The formulæ (12), 13), and (14) speak a clear language, and from them we see clearly what factors determine chiefly the output of an alternating-current motor.

These equations are general, and in the case of a closed-circuit armature according to Dobrowolsky's design, Fig. 2, we have the special condition of $u = 1$, and the armature resistance has to be calculated with the view that all the armature conductors are connected in multiple arc through the two end rings.

(To be continued.)

ELECTROLYSIS OF SEA-SALT.

A very useful property is inherent in electrical processes—namely, of utilising common products. Water is used for generation of current, the air itself is utilised for ozone; and if not so common everywhere as mud, sea salt or sea-water is a fairly common commodity round the shores of our tight little island. We have mentioned the proposed use of sea-water as disinfectant at Havre and other ports—much needing it, to be sure. We may have something further to say about this in conjunction with the Hermite process when the time comes. Meanwhile there is an account in the *Bulletin International* of the Castner process of electrolysis of sea salt which may be interesting to electrical chemists.

Each cell in the Castner apparatus has two compartments, one of which contains the cathode, and the other the carbon anode connected at the bottom by a bath of mercury, which is without appreciable resistance; this is kept in motion by agitators, and rests upon a metal base kept cool by circulation of water. One compartment is filled with water and the other with a concentrated solution of the salt to be electrolysed—chloride of sodium, for instance—mechanically separated by the mercury, a partition, and a projection made of amalgamated metal. When the current passes, hydrogen is given off; this escapes, while the oxygen would combine with the mercury if it were not confined by the sodium, with which it combines to form soda.

If the efficiency of the apparatus were perfect it would be sufficient to start with a small amount of sodium, which would renew itself, but as the efficiency is never perfect (it is usually about 90 per cent.) this must be allowed for. For this purpose the dynamo is first connected to the electrodes so as to pass the current into the mercury until an amalgam is formed, holding about 2/1000 of sodium, after which the second group of electrodes is connected to the dynamo, generating, say, 90 amperes; then the second group is connected to a second dynamo, giving, say, 10 amperes, so that for 100 amperes passing one side there is only 90 amperes passing on the other, precipitating 90 per cent. of the soda theoretically due to the 100 amperes, and giving off the corresponding chlorine, while the composition of the amalgam remains constant at 2/1000 of sodium.

The same result can be obtained by passing the full current for one hour on one half of the apparatus and for nine hours on the other half, and by arranging the cells in series in such a manner as to accomplish this permutation successively in the various cells without changing the potential at the dynamo. With cells in parallel, however, two currents, as mentioned, are employed in proportions regulated by the efficiency of the apparatus.

The solution of sea-salt is renewed by adding solution divested of hypochlorites, and kept in continual circulation, the old solution being treated for the purpose and put into circulation again. The solutions ought not to contain sulphate of calcium or other impurity, as this considerably reduces the efficiency. The solution of sodium is drawn off by a pipe and replaced by water to maintain it at the degree of saturation desired.

The apparatus here is made with three compartments, with two anodes and cathodes in the middle compartment. Three pistons circulate the mercury. Very little mercury need be used—a layer of 3mm. is sufficient. Each of the three pistons displaces at each stroke all the mercury in the compartment, or about a quarter in the whole apparatus, so that the play of the pumps may be quite slow to renew the mercurial surface. The pumps may be replaced by balancing movement arranged to shift the mercury alternatively from one compartment to the other.

The Castner process consists essentially in the use of a mass of mercury continually agitated and traversed by a current in its passage from the anode to the cathode, which are separated by this mercury, so as to disengage from the mercury at the cathode a quantity of sodium precisely equivalent to that precipitated at the anode. This mercury practically replaces the ordinary diaphragms by completely separating the products of electrolysis without introducing any appreciable electrical resistance, allowing at the same time the anode and the cathode to be brought as near as possible together.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

LIFTING WATER BY ELECTRICITY.

SIR,—We have a well about 23ft. deep with an inexhaustible supply of water. We wish to raise that water to a reservoir 500 yards distant, at an elevation of about 80ft. from the well.

Could an electric motor be worked by a cable to work a pump (or anything of a similar nature), if the power was leased from an engine 500 yards distant or from a water-wheel two miles distant?

The quantity of water to be raised daily would be 50,000 gallons. What power would be required?—Yours, etc.,

Chard, October 24. J. G.

CAN ACCUMULATORS BE USED WITH RAILWAY GENERATING PLANT?

SIR,—Will some practical reader give his opinion as to its being practicable to combine the use of accumulators with generating plant for an electric railway. The engine power to be sufficient when the cars are under weigh, but extra current is required from accumulators to ease the engine when cars start, so that the load may be as constant as possible upon the engine. The action must be automatic and not require watching. The present dynamos are compound wound.—Yours, etc., DOUBTFUL.

October 25.

THE

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CONTENTS.

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THE "PALL MALL" v. HARNESS.

The title of this article is not meant to indicate that litigation has commenced between these contending parties, but merely that there exists a little controversy between them. Up to the present time, so far as we know, the writing has been all on one side, but we should dearly like to see a rejoinder. It would be amusing and instructive to see what answer can possibly be given. What is it all about? Our readers will remember that our contemporary the *Electrical Review* not long since found itself involved in a lawsuit because it ventured to criticise the apparatus sold and the methods of doing business by the company over which Mr. Harness presides. The result of this litigation was that the Medical Battery Company was mulcted in damages, and the *Review* had no real opportunity of bringing its case before the jury, and hence before the public. However, a smart writer in the *Pall Mall Gazette* seems to have hunted out this evidence, and has worked it up into a series of articles in that paper. There is no mistaking the meaning of these articles, for throughout a spade is called a spade. Practically, the outcome of the whole series is to say that Mr. Harness is not an educated man, is ignorant of the first principles of electrical science, sells apparatus that is worthless, getting as much as he can for it, and trading generally upon the credulity of mankind, and especially of suffering humanity. Our opinion of this system of trading and these appliances has often been expressed, and we are not so much concerned with Mr. Harness or his doings at present as with a broader question which the action of the *Pall Mall* will, we trust, help to solve. The technical Press with one accord has supported the action of the *Electrical Review*, but the technical Press could only prove troublesome to Mr. Harness, and not fatal till the gross subserviency of the political Press in the matter of advertising any quack nostrum was suppressed. Take the London papers alone, not to mention the country papers, and examine them. It will be found that columns, nay, whole pages of their advertising space has been occupied with the advertisements of electropathic belts, corsets, and other quack nonsense. These papers are supposed to be conducted by educated men, who can at almost any moment obtain the best advice, technical or otherwise. Their leader columns abound in religious, sentimental twaddle, assuring their readers that they love their fellow-men and would die to do them a service. The *Pall Mall Gazette* calls Mr. Harness a liar; we say that the men who pose as one thing in one part of their paper and as another thing in another part of their paper are worse liars. If Harness is perpetrating gross frauds, they are accessories to the action, and in our estimation ten times worse than the initiator of the scheme. The poor suffering beggar who reads these grandiloquent advertisements in the *Standard*, or *Chronicle*, or *St. James's*, or *Illustrated London News*, or any one of the well-known London papers which has permitted their insertion, reasons that there must be something in it or these papers would not give prominence to the advertisement. In a

sense we pity Harness, just as in a sense we pity all clever desperadoes, though we have no word to say in his favour: it is these supporters in the newspaper world that we condemn, root and branch. There is no pity, only contempt, for them. They will sell their souls for a sovereign. Their action is wilful and thoroughly understood. They close their eyes and open their pockets till public opinion is in some way or other roused, and then with a plethora of honeyed words explain that they had never troubled about these matters—it was something not in their department. We therefore give all honour and credit to the *Pall Mall Gazette* in pricking this huge blister, and trust, now that editorial eyes have been, and they must have been opened, that the advertising departments will be compelled to close their doors against such advertisements in the future. A quack may have all the desire in the world to prey upon his fellows, but he cannot do much if the Press closes its doors against him. Mr. Harness is not the only quack, his advertisements are not the only advertisements that are a disgrace, but it is too much to hope that the Augean stable will be thoroughly cleansed. We must be thankful for small mercies. We congratulate the *Pall Mall*; and although Mr. Harness is said to be going to vindicate his honour, and the *Evening News* seems inclined to support him in that it publishes "with pleasure" an exceedingly silly letter or circular sent broadcast to scientific men and learned societies, in which Mr. Harness asks for a "commission of investigation," we do not think the *Pall Mall* need fear the result. A "magnetic or electric corset," or whatever they call it, as sold by the Electric Battery Company does not want a minute's scientific investigation. Is "Mr. Harness" or the *Evening News* credulous enough to think scientific men are going to solemnly sit in investigation of things of that sort? But enough; if the *Pall Mall* can stop the advertisements it will have benefited the whole country, and will certainly stop the sale of these unscientific and useless appliances.

The preceding sentences were written before the *Pall Mall* of Thursday was seen, and we were glad to learn from it "that several newspapers have refused to be any longer the means of bringing Harness's wares before the notice of their readers." Further, the same issue corroborates what is said above, in that we are told "many of the victims whose letters have reached us assert that they would never have given the belts a trial had they not seen them advertised in papers whose respectability and reputation were above suspicion." The *Pall Mall* then goes on to excuse ignorance of what is advertised; but we maintain there is no valid excuse. The conductors of the newspapers know that the advertisements come from men outside the medical or electrical profession; they know, indeed, that they come from quacks, and knowing that, they ought to get technical advice—if the fact in itself is not held to be proof positive against the insertion of advertisements.

These articles in the *Pall Mall* may not be verbally correct—there may even be doubtful scientific statements, but the broad facts are there and cannot well be denied. The crusade begun ought to be continued with vigour till the plague spot is stamped out.

REVIEWS.

The Dynamo: Its Theory, Design, and Manufacture. By C. C. Hawkins, M.A., and F. Wallis, A.I.E.E. Whittaker and Co.

(Concluded from page 326.)

The magnetisation of iron forms the text of Chapter XII., and the knowledge of to-day is fairly summarised, especially those points that influence dynamo construction, such as permeability and hysteresis. The authors maintain that "permeability" "differs decisively from the analogous property of conductivity." In this, however, they can hardly be held to follow the most progressive electricians, who seem to be coming more and more to the view that magnetic and conductive phenomena do not "differ decisively." Hopkinson's experiments and Ewing's developments and theories are clearly given. A chapter on armatures follows, the matter discussed referring as much to mechanical as to electrical details. Thus we have information as to the strength of shafts, the methods of building armatures, Crompton's plan for getting rid of eddy currents and their evil heating effects, the connection with and the construction of commutators. Chapters XIV. and XV. deal respectively with the field magnets and the ampere-turns of the field, and are worth careful study, although we think condensation might have been practised with advantage. Still, it is better to repeat than to fail to drive home the point under consideration. The decrease of permeability with magnetisation is again insisted upon, hence to work with the field beyond the point of saturation is wasteful. The materials for the construction of and suitability for field magnets are discussed, as are the various types of fields adopted in practice, mechanical as well as electrical questions being constantly kept in view. We could wish the authors had assisted the reader by still more repetition, even at the cost of slightly increasing the bulk of the book. For example, take the commencement of Chapter XV., reference is made to illustrations in Chapter III., and again to Chapters III. and XII. The reader would be assisted by a repetition of these illustrations, especially as neither page nor number of figure referred to is given. Again, after such a decisive contention in Chapter XII., we might have expected something different from Ohm's formula in Chapter XV., page 287: "We may express the fundamental equation for the ordinary bipolar dynamo with its two air-gaps, one on either side of the iron armature, in the following form:

$$\text{"Total M.M.F.} = H_a\, l_a + H_g\, 2\, l_g + H_m\, l_m."$$

If this is not absolutely and without reservation of any kind whatsoever analogous to

$$E = C\,R,$$

we do not know what it is. Solely because this fact fails to gain recognition, we have to encumber our books and papers with equations which frighten folks by their seeming complexity; yet the equations are reducible to the simplest form. To us these funny equations are ridiculous. Just as well put another term into the equation while you are about it, and recognise that the armature core has a different magnetic resistance per unit area to that of the field magnet because there is less magnetic volume in the unit volume of the armature than of the field magnet. We take it that this must be so in that some space is occupied with insulating material in a cubic centimetre of the armature core, and no such space is occupied in the field magnet. What we want is the total magnetic resistance of the particular circuit we are dealing with, and not the separate resistances that go to make up that total, except as an analytic detail when we are endeavouring to design a machine with total resistance as small as possible. Given however, that we must be tortured with this cumbrous notation, the authors use it as deftly as anybody, and, as we say, have put a lot of really valuable matter in these

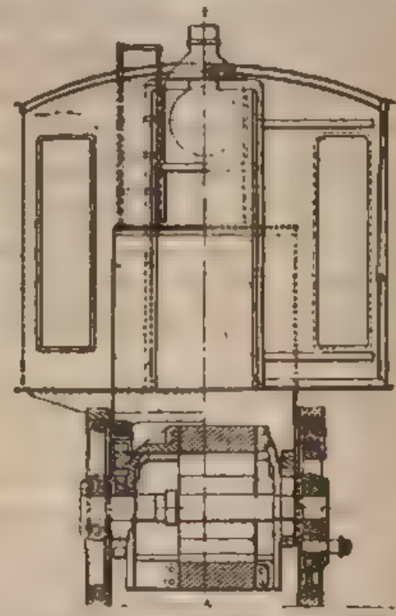
chapters, among which that relating to leakage is prominent. The description of the various kinds of winding, with the characteristic curves obtained, is next found, followed by a chapter on sparking and the angle of lead, in which is epitomised almost the whole of the existing knowledge on the subject. The careful reader will probably come to the conclusion that the best design of dynamo must be that in which the various compromises are most happily arranged. The whole is a question of give and take. After a chapter on heating of dynamos is given careful descriptions, with dimensions, of typical dynamos—a chapter of the utmost importance, for undoubtedly the designer will start from what is in existence, and modify these existing designs to suit his own requirements or foibles. Except we are to have a new departure, as suggested by Mr. Sayers, there does not seem much latitude for improvement in machines that give over 90 per cent. electrical efficiency. But the authors do more than describe machines; they show, in Chapter XX., how to design machines, using the information given in the previous chapters, and conclude with a chapter on the working and management of dynamos.

We have thus attempted briefly to indicate the contents of this volume—a volume in which the information given shows the authors to have ransacked the literature of the universe, and in a measure to have abstracted the wheat, though some readers will think there still remains a little chaff. The labour which has been spent upon this book can hardly be realised by those who do not know the trouble it takes to examine the *Transactions* of various societies, and to get at the pith of the papers contained in these *Transactions*. The book is well printed, amply illustrated, and furnished with a fairly good index. The motto of the authors in preparing a future edition should be condensation and simplification.

A POWERFUL ELECTRIC LOCOMOTIVE.

The scream of the American eagle is as a rule very offensive to many in this country who prefer slow but solid progress rather than undue or miscalculated haste, but the fact remains that while crowds gather together in England simply to look at an ordinary electric tramcar on the street, practical American engineers have taken a much greater step forward in electric traction, and are actually building electric locomotives of a very powerful type for special uses and purposes which do not involve great expense for new permanent way, etc., apart from the engines themselves.

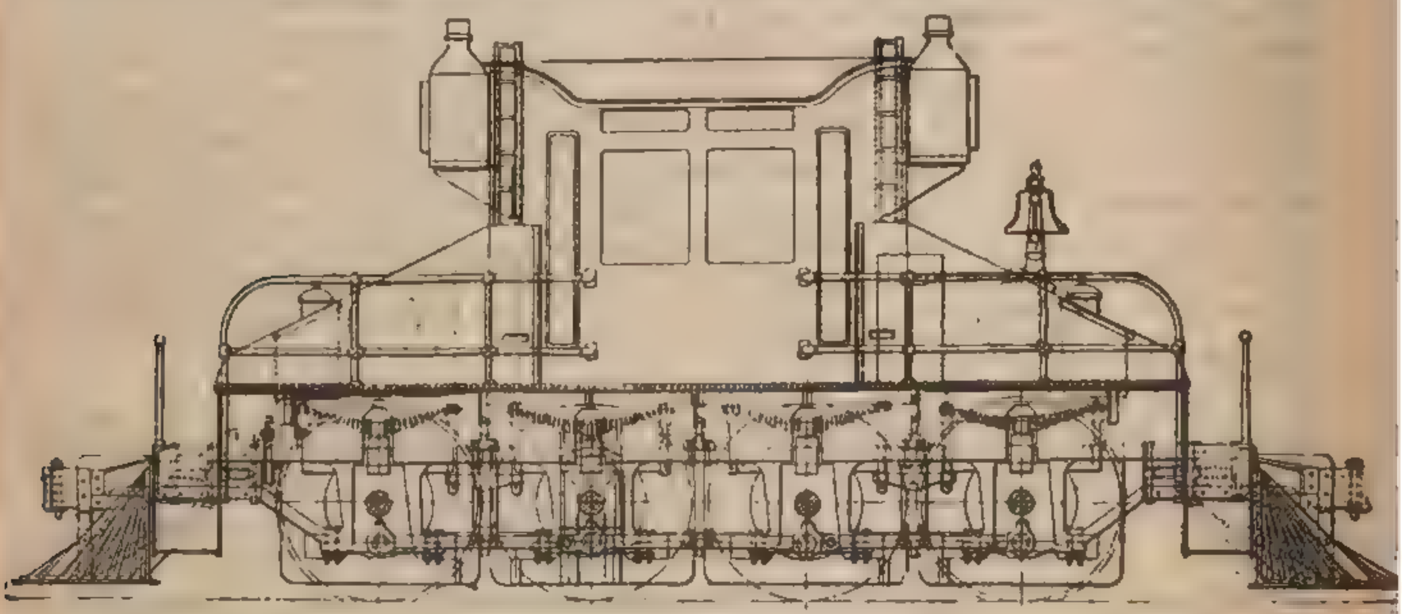
We have already chronicled — with full details and illustrations—the equipment of two large electric locomotives—weighing 30 tons and 90 tons respectively—by the General Electric Company, of Boston; and particulars are now to hand of another powerful engine, built to give an output of 1,000 h.p. The authors of this design are the well-known consulting electrical engineers of New York—Messrs. Sprague, Duncan, and Hutchinson—under whose supervision the locomotive is being built to the order of the North American Company. At first it will be used specially for experimental work in shunting and marshalling goods trains and waggons, being designed for that



Powerful Electric Locomotive.—End View.

purpose, with heavy traction at slow speeds. The armatures and electrical equipments generally are from the works of the Westinghouse Electric and Manufacturing Company, whilst the running parts, framework, etc., have been constructed at the Baldwin Locomotive Works, Philadelphia, where the whole engine is being erected.

The general features of this new locomotive are shown in the illustrations. The frame is of steel, with exceptionally deep pedestals, and is arranged to receive four pairs of boxes fitted with the usual adjustments. The pedestal boxes are of a special form, are made of cast steel, and project inward to form the brackets which carry the motors. The lower sides are arranged to be dropped out, so that the brasses can be readily replaced. These boxes render the double service of carrying the axles upon which the armatures are rigidly mounted and the field magnets concentric to them. A stirrup projects from the upper portion of each to engage the middle section of inverted elliptical



Powerful Electric Locomotive.—Side Elevation.

springs, the four sets of which are arranged on the double three-point suspension system. In this way the whole is carried on equalising springs.

The driving wheels are 56in. in diameter, the first and last pairs only being flanged. They are close coupled, with only 4in. between the faces, and the connecting-rods are jointed.

It will be noted that the weight of the armature is directly on the wheels, and not on the journals, while that of the field magnets is on the journals through the pedestal boxes. There is thus absolutely no spring support of any kind provided for any part of the motors. This is contrary to the prevailing opinion of what is necessary in a machine of this type, as, for instance, on the motor cars of the Liverpool Overhead Railway, or the locomotives of the South London Railway. Another difference distinguishing this locomotive from the large one designed by the General Electric Company for the Baltimore and Ohio Railroad is that the system is a unit, the motors all forming part of a single system having a rigid wheel base of 15ft., and coupled together by quarter-cranked connecting-rods instead of having two or more bogie trucks with independent, spring-supported motors.

Among the considerations that led to this design, however, were the simplicity and directness of application, the impossibility of operating two or more motors in series satisfactorily on a slippery track when the full tractive effort is required of them without a mechanical coupling, and the likelihood that with large drivers, each flexibly connected to the system, the troubles anticipated from rail impact would not be as serious as had been commonly supposed. The motors are of the "Continental" iron-clad type, the field magnets being formed of two steel castings, and having two field coils placed at the ends of the motors with their planes vertical, thus forming two consequent and two salient poles. The magnets are compound wound, the shunt field being light and only sufficient to keep the speed within reasonable limits at light loads and for returning current to the line, by acting as in a generator, when running downhill. The armatures are of the slotted type, the slots having curved bottoms and tops and contracted gaps. Each slot carries four wires, but there is only one turn of wire to each bar of the commutator, and the wires are threaded through tubes embedded in the slots. The winding is of the two-path type, giving the current only two paths in the armature. The dimensions of the latter are: diameter 31in., length of active part 21in., number of armature coils 237. The height of the steel casting over all is 46in., and the clearance from the top of the rail 5in. The induction in the teeth of the armature is very high, reaching as much as 22,000 C.G.S. lines.

The motors are wound for 800 volts at 225 revolutions, thus being the equivalent of 35 miles an hour when running in parallel. They will safely carry 250 amperes, thereby giving each motor at that speed an output of some 250 h.p., with an efficiency of 93 per cent. On emergency they might even stand more than this. A drawbar pull of 30,000lb. is readily exerted at a speed of 12 miles an hour, and a system of regulation is provided to give any speed from zero up to 35 miles an hour under the full normal tractive effort. The method of regulating is of the series-parallel type, a resistance being thrown in, then cut out, then again thrown in while changing the combinations of motors. The latter may be grouped, first, all in series, with or without the variable resistance; next, two in parallel by two in series; then all four in parallel, with a similar use of resistances at each change. All the motors are operated together, none, that is, being entirely cut out of circuit. These various changes are effected by means of a large contact cylinder, on which the three main combinations are made, and a fireproof resistance frame with the contact arm geared suitably with the main cylinder.

This controlling system can, of course, be moved by hand, though somewhat slowly, because of its massive nature. To effect more speedy changes, power is employed in the shape of compressed air from the Westinghouse brake air-reservoirs, automatically kept at a constant pressure by a special electric pump. In order to avoid any necessity for the driver's attention to be distracted from signals, etc., on the line, or other objects outside the cab necessary for him to watch (as might be the case if he had to turn one handle after another in operating), the controlling air valve is mounted on a small lever so geared as to move backwards and forwards with the main regulating cylinder. His hand is thus carried along with the cylinder; he knows the exact position of the latter by touch, and can use his eyes for watching outside affairs.

A reversing switch is provided, but is automatically locked, except in the "off" position of the main cylinder. Other accessories—measuring instruments, etc.—are also at hand for use as required, all of them in the cab in front of the driver.

The total weight of the locomotive mounts up to nearly 60 tons; and it is therefore by much the most powerful engine as yet actually constructed. For the details and illustrations we are indebted to the *Railroad Gazette* of New York.

In any attempt to criticise the general design of this engine, it is sufficient now to take one point only; the minor details (as might be expected from those responsible for the plan and execution) are well thought out, and will doubtless require little change. The main point at issue is rather one of an economical nature. Instead of aiming at high speed and light loads, the designers have gone to the other extreme, and endeavour to employ electric traction for heavy goods traffic, where low speeds and high tractive efforts are required. Of course this can be done quite easily (and the mere fact is enough to show the extraordinary elasticity of electric traction), but we doubt at present whether the economical results will be so good in the one case as in the other. Probably the experiments to be carried out with the locomotive under notice will help very materially to clear up this point; if so, the workers in electric traction will owe a considerable debt of gratitude to pioneers such as come forward "across the water."

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE III.

Transmission of Power by Wire-Rope Cable.

The origin of the system of telodynamic transmission is interesting. In 1850 there were some large factories at Logelbach, near Colmar in Alsace which had been standing idle since 1841. It was a question of starting these again as factories for weaving. But there was only one steam engine, and the buildings were scattered at considerable distances.† It occurred to M. C. F. Hirn to drive one of the factories at a distance of 80 metres from the steam engine by a steel band, used like an ordinary machine belt, on wood pulleys two metres in diameter, and making 120 revolutions per minute. The steel band was about 2¼in. wide and $\frac{1}{24}$in. thick. This band was used for 18 months, transmitting 12 h.p. Then an English engineer, Mr. Tregoning, suggested the use of a wire-rope cable. A cable of ½in. in diameter was procured from Messrs. Newall and Co., and replaced the steel band in 1852. The same pulleys were used with a groove turned in the rim ½in. deep. That cable worked for years, the pulleys, however, being replaced by iron pulleys. A second transmission, to a distance of 240 metres, was soon erected, with pulleys 10ft. in diameter, with a cable ½in. diameter, running at a speed of about 30ft. per second and transmitting 40 h.p. Supporting pulleys were used at the half distance. These transmissions are still working.

M. Hirn has confessed that his chief difficulty at first was the construction of the pulleys. It was not till he adopted a pulley with a dovetailed groove filled with guttapercha, that he felt the problem of telodynamic transmission to be solved. With these pulleys neither the pulley nor the cable suffered excessive wear.

The amount of work transmitted by a cable is proportional to the product of the effective tension in the cable and its speed. To transmit power to great distances by manageable cables the strongest material must be used for the cables, and they must be run at the highest practicable speed. The cables were at first of iron, now they are generally of steel. The largest cable which it appears to be practicable to use are about 1in. in diameter. In order that the bending stress may not be excessive the pulleys are of large diameter, 12ft. to 15ft. usually. For the throat of the

* Howard Lectures delivered before the Society of Arts.

† "Notice sur la Transmission Telodynamique," C. F. Hirn, Colmar, 1862. "Note sur la Transmission Telodynamique inventée par M. C. F. Hirn," par M. du Pré, Bruxelles, 1869. "Erfahrungs Resultate über Betrieb und Instandhaltung des Drahtseiltreibs," Ziegler, Winterthur, 1871.

TABLE OF TELODYNAMIC TRANSMISSIONS.

Place.	Total H P trans-mitted.	H P. on one rope.	Total distance of trans mission.	Diameter of pulleys in inches	Velocity of rope in feet per second.	Diameter of rope in inches.	Diameter of wires in inches.	No. of strands.	No. of wires in each strand.	[illegible] No. of wires.
Ober Ursel . . .	104	104	3,170	148	73	·63	·07	—	—	48
Schaffhausen	560	280	2,700	177	62	1·08	·072	8	10	80
,,	—	150	-	177	—	·88	—	—	—	60
Fribourg . .	300	300	2,510*	177	62	1·08	·072	10	9	90
,, . . .	—	50	—	108	—	·64	·043	8	9	72
,, .		120	—	148	—	·72	·060	6	[illegible]	66
,, .	—	60	—	148	-	·48	·054	6	6	36
,, ..		20	—	84		·36	·036	7	6	42
Bellegarde	3,150	300	—	216	65	1·28	·088	8	9	[illegible]
Tortona . . .	8	8	—	78	—	·43	·039	6	8	48
Zurich . . .	250	150	2,500	186 & 127	65	·80	—	—	—	—

* The total distance of transmission at Fribourg is 6,500ft.

pulley, on which the rope runs, guttapercha, soft wood, and leather have been used. At present the bottom of the pulley groove is usually formed of strips of waste leather forced into a dovetailed groove. The greatest speed of rope practicable to adopt is that at which the centrifugal tension of the pulley rims becomes dangerous; 100ft. per second has been adopted as the greatest practicable speed. The pulleys are placed at maximum distances of 300ft. to 500ft. apart. The weight of the rope then ensures sufficient adhesion to prevent slipping, when the ropes are tightened so that the deflection or sag is not inconvenient. With these limitations, a 1in. rope will transmit about 330 h.p. In 1854, M. Henri Schlumberger transmitted the power of a turbine a distance of 80 metres to drive agricultural machinery. In 1862, M. Hirn stated that he knew of more than 400 cases of wire rope transmission. In 10 years, M. Stein, of Mulhouse, is stated to have constructed more than 400 telodynamic transmissions, carrying an aggregate of 4,200 h.p. an aggregate distance of 72,000 metres. It may be mentioned here that the largest telodynamic transmissions have been constructed by Messrs. Rieter Bros., of Winterthur.

General Description of the System of Transmission by Wire-Rope Cable.—The cables used are stranded ropes having six to twelve wires in each strand, and six to ten strands in each rope, Fig. 13. The strands are twisted on a hemp core, and usually there is a hemp core to each strand. The hemp makes the ropes flexible. At first, Swedish charcoal iron was used; now the ropes are more commonly of steel. They are protected from oxidation by a coating of boiled oil. It is necessary to keep a spare rope in reserve, in case of accident.

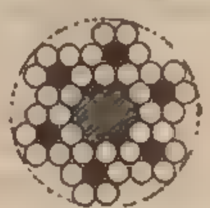


FIG. 13.

The ratio of the tensions in the tight and slack sides is about 2 to 1. In passing round the pulleys the rope is bent, and the bending stress is added to the longitudinal stress. In order that the bending stress may not be excessive, large pulleys must be used. Their diameter is so chosen that the bending stress and longitudinal stress are about equal. As the tension in the slack side is less than that in the tight side, supporting pulleys for the slack side may be smaller than the driving pulleys. The accompanying table gives data of the most extensive cable transmissions.

The stretching of the rope when first erected has given rise to some trouble. The hemp cores are compressed, and the rope diminishes in diameter and stretches. Then it requires resplicing, a troublesome operation. To diminish the difficulty thus caused, Messrs. Rieter Bros. pass the ropes before use between grooved compressing rollers. In 10 to 15 passages of the rope it stretches from 1 to 4 per cent. in length, and its diameter diminishes about 6 per cent.

The piers supporting the pulleys being expensive, and the pulleys themselves being a cause of waste of power, it is desirable that in a wire rope transmission the spans should be large. Spans of 300ft. to 500ft. have been commonly adopted. On such spans the deflection of the rope is considerable, and must be provided for by making the pulley piers high enough to keep the cable off the ground. The deflection of the slack side of the rope is greatest, and hence very often the slack side is placed above the tight side.

Arrangement of Spans.—Fig. 14 (I.) shows an ordinary single span with the deflections of the tight and slack sides of the rope. If the deflection is inconveniently great, it may be diminished by an intermediate supporting pulley Fig. 14 (II.). When the distance of transmission is too great for one span a single endless rope may still be used with intermediate supporting pulleys. In some cases it is convenient to have more supporting pulleys for the slack than for the tight side of the rope. At Frankfort, Ziegler constructed the spans with independent ropes. Then the pulleys at intermediate stations must be double grooved. This is the arrangement generally adopted by Messrs. Rieter Bros., of Winterthur. Prof. Reuleaux has proposed the arrangement in Fig. 14 (V.) to reduce the height of the supporting piers. The spans of the slack side of the rope are half those of the tight side, so that the deflections are nearly equal.

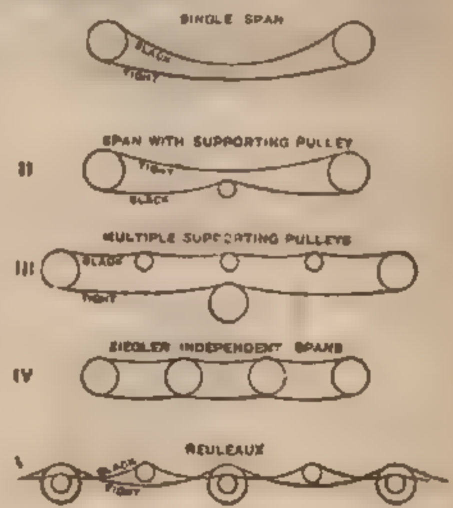


FIG. 14.

In order to give the wire rope a greater frictional hold on the pulleys, and also to increase its durability, the pulleys have wide V-grooves, bottomed with some softer substance than iron, Fig. 15. At first Hirn used guttapercha pressed into a dovetailed groove; then pinewood strips were used; now, almost universally, strips of leather are pressed into a groove in the pulley edgeways. The pulleys are of cast iron, or of cast iron with wrought-iron arms.

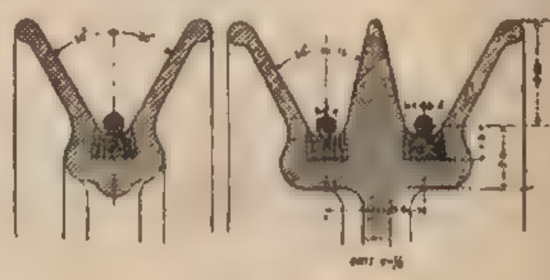


FIG. 15.

As the principal part of the waste of work is due to the weight of the pulleys, they should be made as light as possible. The leather packing in the groove requires renewal every three or four months, and involves a not inconsiderable cost of maintenance. The pulley stations are necessarily costly, being lofty, and requiring to be substantially constructed. They are of timber, of iron, or of masonry. Change of direction of the rope has hitherto invariably been effected by bevel gearing. Fig. 16 shows one of the masonry piers of the Bellegarde transmission. Fig. 17 is a change station, where the direction of the ropes is changed. Reuleaux has proposed changing the direction by guide pulleys, Fig. 18, which would doubtless waste less work.

Efficiency of Rope Transmission.—The two principal sources of loss of work in telodynamic transmission are the friction of the journals supporting the pulleys and the resistance due to the stiffness of the rope. Ziegler's experiments at Ober Ursel gave for the friction of the journals at one pulley station 1·14 h.p., and for the work expended in bending the rope 0·625 h.p., a total of 1·765 h.p. at each pulley station. When transmitting full power, the efficiency of the system is remarkably high. No other mode of transmission to moderate distances involves so little loss of work except electrical transmission. If from Ziegler's experiments the efficiency of each span is taken at 0·962, then for a transmission

of m intermediate stations, or $m + 2$ stations altogether, the efficiency is $\eta = 0{\cdot}962^{\frac{m+2}{2}}$.

Number of stations ($m + 2$) . .	2	3	4	5	6	7
Efficiency.	0·96	·94	·93	·91	·89	·87

This, however, gives the full load efficiency; with diminished load the loss remains nearly constant, and the efficiency is less.

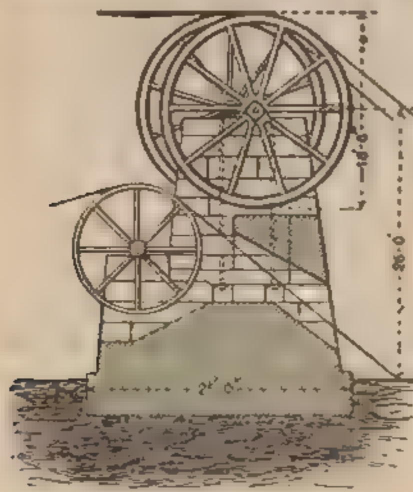


FIG. 16.

The Ober-Ursel Transmission.—Not long after the invention of Hirn's system of wire-rope transmission and its application at Logelbach, an opportunity occurred for trying it on a more considerable scale. A cotton mill had been built at Ober Ursel, near Frankfort, to utilise the water power of the Urselbach. Two

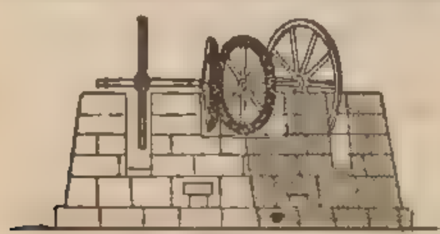


FIG. 17.

tangential wheels were erected on a fall of 165ft. Their total power varied from 64 h.p. to 150 h.p., according to the condition of the stream. In 1860 more power was required. A fall was found above the mill of 264ft., but at a distance such that it could not have been made available by ordinary means of transmission. On this fall two tangential wheels were erected, each yielding from 40 h.p. to 104 h.p. according to the condition of

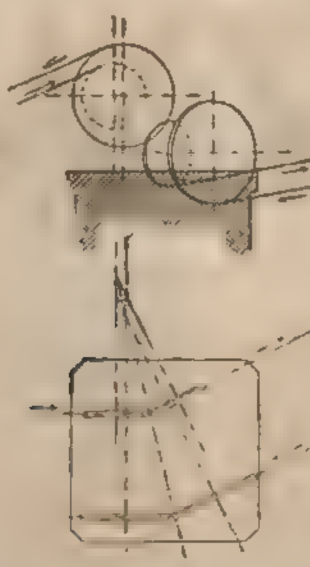


FIG. 18.

the stream. The water from the upper turbines afterwards drives the lower turbines. From the upper turbines the power is transmitted by wire rope cable a distance of 3,160ft., in seven spans of about 400ft. The pulleys are $12\frac{1}{2}$ft. in diameter, and the cable $\frac{3}{4}$in. in diameter. The pulley grooves were lined with leather strips driven edgeways into a groove, a plan now commonly adopted. The pulleys run at $114\frac{1}{2}$ revolutions per minute, and the rope speed is 73ft. per second. The pulleys on the intermediate piers are double grooved, a separate cable being used on each span. Perhaps this was the first completely successful application of telodynamic transmission on a large scale. The work was carried out by Messrs. J. J. Rieter, of Winterthur.

The Ochta Installation.—In 1864, after a serious explosion, the gunpowder factory at Ochta, near St. Petersburg, was reconstructed, and wire-rope transmission was adopted, in order to secure the condition that the dangerous buildings should be at a distance from each other. The motive power of the new factory was supplied by two turbines of 140 h.p. each. A reserve turbine was also erected. The buildings were erected in three lines, one in line with the principal axis of the turbine house, one parallel to, and 420ft. behind, the former; a third at right angles to the first in line with the shorter axis of the turbine house. In each line the buildings nearest the turbine house were 330ft. from it. In the first line there were eight buildings requiring 100 h.p., and the buildings were 164ft. apart, centre to centre. The second line contained 12 buildings placed 230ft. to 330ft. apart, and requiring 80 h.p. The third line contained three buildings, requiring 24 h.p., and placed about 300ft. apart. There were, therefore, 23 buildings, widely scattered, to be supplied with power. The greatest lengths of transmission are 1,300ft., 2,300ft., and 2,600ft. The power was transmitted by wire-rope cables, the work being carried out by M. Stein, of Mulhouse.

The Schaffhausen Transmission.—A still more considerable application of telodynamic transmission, which attracted general attention, was made soon after at Schaffhausen.* After a period of trade depression there was a revival of industry at Schaffhausen between 1840 and 1850. In the year 1850 Herr Heinrich Moser, of Charlottenfels, constructed a canal, and erected the first turbine at Schaffhausen. It then occurred to him that it might be possible to render useful the immense volume of water passing down the rapids of the Rhine in front of the town. An extraordinary low condition of the river in the winter 1857-8 favoured an examination of the bed of the river, and a commission was appointed to mature a project. This commission suggested the formation of a weir across the river, the construction of a power-house on the right bank, with turbines of 500 h.p., on a fall of 4ft. to 6ft., and the transmission of the power across the river to the factories by the then new system of telodynamic transmission. The cost was estimated at £20,000.

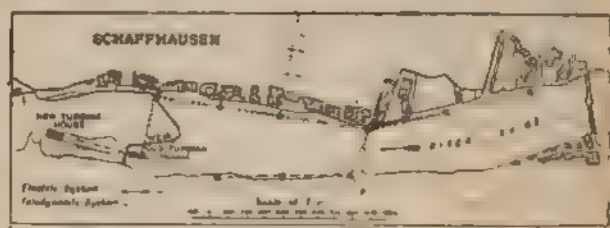


FIG. 19.

Fig. 19 shows the general arrangement of the works at Schaffhausen, with the old turbine-house for the cable transmission, and the new power house for electric transmission, which will be described later.

(To be continued.)

ON THE ARTIFICIAL LIGHTING OF WORKSHOPS.†

BY BENJAMIN A. DOBSON, OF BOLTON.

In manufacturing districts the use of artificial light is of considerably greater importance for work of all descriptions than it can be elsewhere. Whether the work be fine or coarse, delicate or bold, a better light is needed than for work which does not come under the head of manufacture. In Lancashire the staple industries of engineering, machine-making, spinning, weaving, bleaching, and dyeing, are mainly established in certain centres; and with them is invariably associated in the surrounding district the great coal industry. Although Lancashire coal has a number of excellent qualities, yet it is one that makes the most smoke of any. A large portion of the manufacturing industries, great and small, date from a number of years back, when smoke-consuming and smoke-preventing apparatus had not yet been devised; and many of the factories are working at the present day under pretty much the same conditions as when they started. Hence the atmosphere in all manufacturing towns in Lancashire is heavily charged with unconsumed carbon, producing an excess of cloud and fog, which, while inducing an excess of rain, acts also as a screen against the rays of the sun, and thus does a double injury to the neighbouring agriculturist, the producer of the country's native wealth. A circle of 30 miles radius around Manchester is said to include a larger population than an equal circle around any other place in the world, and within this circle, about 12 miles north-

* "Turbinenanlage und Seil Transmission der Wasserwerkgesellschaft in Schaffhausen," von J. H. Kronauer, Winterthur, 1870. "Die Wasserwerkgesellschaft in Schaffhausen," Schaffhausen, 1889. "Funfundzwanzigster Jahresbericht der Verwaltungsrathes der Wasserwerkgesellschaft in Schaffhausen, 1889." Schaffhausen, 1890.

† Paper read before the Institution of Mechanical Engineers.

west of Manchester, lies Bolton, the town with which the author is best acquainted, where all winds, except the west and north-west, bring the surcharged atmosphere from other manufacturing districts, producing at any season of the year, if the wind happens to be slight, a sky ranging from dull lead to dark brown. For four years in succession it has occurred at the writer's works, that on June 21, the longest day, the gas in every room, amounting to nearly 7,500 jets, has had to be lighted by 11 o'clock in the morning, and has remained lighted until work ceased, and this has occurred also in other towns, and in weather that ought to have secured abundant sunshine. To such an extent does gloom prevail that in clear weather the effect of bright sunlight becomes even distressing to the eyesight, simply from the rarity of the contrast.

Requirements for a Well-lighted Workshop.—Firstly, the light, if artificial, should be sufficiently intense to give the power of clear and natural sight over any portion of the work. For enabling the work to be performed with ease the light should evidently be arranged to produce as nearly as can be the effect of natural sunlight. The light of the sun is diffused by the atmosphere; and unless its entrance is limited in extent, such shadows as it may produce are only natural shadows, so natural that the eye has no difficulty in following detail in any visible part. In this respect, therefore, artificial light should as far as practicable imitate the best natural conditions.

Secondly, the light should be so diffused as to avoid casting shadows, or placing any one portion of the work in too great relief as compared with the general tone of the whole. If the work were being done in front of a window which faced the sun, a certain portion of it would receive an undue amount of light, and give a false idea alike of size and distance, owing to the contrast of the overlighted and underlighted parts. This might be a natural light, but would nevertheless be improper.

Thirdly, the light should be of such a character as to have no tendency to injure the sight by a blinding glare. This remark applies either to a good gas flame or to the electric incandescent lamp, from both of which the light is fairly well diffused. The rays being all comparatively weak are easily diverted, and thus distributed. But the effect of having either a bright gas flame or the still brighter coil of glowing wire before the eyes is exceedingly fatiguing and destructive to the sight, and in combination with the dust of workshops makes it a wonder that ocular diseases are not more common than they are.

Fourthly, the light should be of such a character as to leave the atmosphere free from noxious emanations. Any kind of natural or electric light will fulfil this condition. The artificial light that most infringes it is gas, which varies much from town to town, and even in the same town from time to time; but it is generally so impure as to be deleterious to health and comfort in the products of its combustion, which is always more or less incomplete.

Fifthly, the light should not unduly raise the temperature of the room in which it is employed. If on a hot day a gas burner has to be lit for every person in a crowded workshop, as has to be done in certain manufactories, the combustion of so much gas affects the temperature greatly, and thereby produces lassitude among the workpeople, together with various ailments which are almost in proportion to the amount of gas consumed.

Sixthly, the light should be simple, and capable of easy control. The whole arrangement should be so contrived that nothing but the simplest knowledge and experience are required for turning the light on and off. This implies, of course, both a central control and also various points of sub-central control.

Seventhly, the cost should be kept within such limits as will render the light practicable at the present day for those who have to make their livelihood in their special trade in open competition with the rest of the world.

Electric Lighting by Inverted Arc Lamps.—Some years ago, while engaged in visiting and examining certain mills on the Continent, the writer was much struck with a mode of lighting which he then saw for the first time. This consisted in the use of electric arc lamps of from 1,600 c.p. to 2,000 c.p., suspended in a white enamelled reflector at a certain distance below the whitewashed ceiling of the mill. The first he saw was of 2,000 c.p., and thoroughly lighted a large room of about 40ft. square with light sufficient to see to pick up a pin off the floor. The walls of the room, as well as the ceiling, were whitewashed. The light had a sort of bluish tinge, and looked like bright moonlight, but with much greater illumination and entirely without shadows. This appeared so striking that he made a few experiments at once, and found that it was possible to see into the interior of the machines and even underneath them in a way that up to then would have seemed incredible; and, further, that it was not possible to make a shadow of any description, even when holding a hat only 2in. above the floor; all that could be seen in the centre of the covered part was a comparatively slight deepening of the shade. In other departments of the factory he found the same plan equally effective, and the diffusion of light so complete as to be astonishing.

Incandescent Glow Lamps.—At that time the author's firm were engaged in replacing gas by incandescent glow lamps on the Edison Swan system in a large machining-room at their own works, which is 345ft. long by 76ft. broad and only 12ft. high, containing 239 machines tended by 200 workpeople in the area of 26,220 square feet. The exigencies of trade had required that annexes should be constructed almost all round the building, thus further diminishing the amount of natural light that could gain admission. Along the whole of the centre of the shop, for a breadth of some 50ft., gas was burning day and night; and in the close muggy weather of autumn and the fog-laden days of hot summer, the atmosphere of the room became most oppressive, in spite of the best ventilation by Blackman propellers; even at six o'clock in the morning, on entering the room, the smell was most objectionable. It was noticeable too that an undue proportion of the men suffered from diarrhœa, which was, in fact, a standard complaint, and furnished the constant explanation for absence from work. Although sometimes this was simply an excuse, there can be no doubt that the exhalations caused by the imperfect combustion of a gas not absolutely pure will suffice to explain the possibility of a large number of men being affected thereby.

The incandescent glow lamps, each with its own switch, and covered with a wire guard, were attached to the gas brackets, which for this purpose were left just as they had been. Within a week of the application of these lamps the importance of the third requirement, with regard to glare, was amply proved, for nearly every workman had devised a shade of one kind or another, some of white or brown paper, some opaque, and some translucent. No better device than this has been found; it does not look neat, being simply a makeshift, but it answers the purpose, costs nothing, and is applied in a moment. The results of the alteration were curious: the atmosphere was improved, the heat considerably diminished, diarrhœa as a general complaint ceased, and was at first succeeded by bronchitis, which, however, was found to be of a temporary nature, and disappeared as soon as the workpeople in that room had become acclimatised.

Nevertheless, with the result of this lighting the author was not satisfied. The shop was as dark and gloomy as with the previous gas lights. The number of lamps broken by accident and by carelessness was so great as to become a serious consideration, their price being out of proportion to their actual cost, and no allowance being made in regard to royalty in replacing broken lamps which had already paid royalty. The writer then made two further journeys to the Continent, in order again to examine the plan of the inverted arc lamp; and on the first occasion returned more favourably impressed than before. The second journey was, therefore, made with the view of going more thoroughly into the details, and of concluding arrangements for conducting a trial of the plan in his firm's establishment. On this occasion he had the opportunity of examining a large weaving shed at Ruysbroek, near Brussels, on a dark winter night. The dynamo was driven from the main engine of the mill, and was a fine piece of work. Corridors lighted by incandescent lamps led thence to the vast weaving shed, which had the usual roof containing glass panels almost upright facing north, with a plastered ceiling sloping southwards from the top of each glazed panel, and lighted from an inverted arc lamp in each bay between the pillars. The impression upon entering the doorway was that the large room was brilliantly lighted by the mid-day sun: no glare, no flames to be seen, but a golden light pervading the whole of the vast enclosure, the colour of the hair, complexion, and costumes of the workwomen perfectly distinct, under the looms not the slightest trace of shadow. In fact, the result attained was an absolutely perfect ideal light for textile work. The bluish tinge of the arc light itself, when lighting direct, is more apparent than real, because it does not prevent the most delicate shades of colour from being appreciated. If, however, it is considered disagreeable or undesirable, it can be altered as it was in this particular weaving factory, by mixing a trace of yellow with the ordinary whitewash; the ceiling is then still white, but the apparently bluish tinge is eliminated.

The result of this visit was the application of four inverted arc lamps in the large low machining-room at the writer's works. Over 50 tons of castings are daily taken in and out of this room, and there must be at least 300 tons of castings of various sizes and descriptions, in progress of treatment, stacked and piled in different places on the floor. There is, therefore, all the more necessity for good lighting in order to avoid accidents. The darkest portion of the shop was chosen, and the four arc lamps were placed in approximately the best positions for lighting a certain area. The ceiling not being plastered, it was considered advisable to nail up to the joists light scantlings, which were afterwards whitewashed. These lights have now been running almost day and night for about two years, and with unqualified success. The four arc lamps have replaced 26 incandescent lamps; but whereas each incandescent lamp lighted up its own work only and a few inches around, the whole of the area lighted by the four inverted arc lamps is bathed in a gentle temperate light, absolutely equal in all parts. This was encouraging, as an arrangement of this description involves a heavy expenditure, and

it was therefore considered advisable to have further experience before going more largely into it. Moreover, this plan of lighting would not always be applicable. If the ceiling were very low it would scarcely be practicable, because the arc lamp must hang a certain distance below the ceiling and still leave head room. Also there are places where the amount of light required is so small that it would be injudicious to go to the expense of applying these lamps, which are capable of so much more duty. It was determined, however, to make an experiment on a practical scale at the author's works, and with this object to apply inverted arc lamps for the lighting of a three storey building with large attic floor above, the latter being used as an iron and wood pattern-room.

Fire Insurance.—With the object of avoiding any difficulty in the future it would seem advisable, before proceeding with the further development of the plan of inverted arc lighting, to consult the insurance companies in each individual instance. The old style of insurance, where heavy risks were taken by one or two companies only, has now been altered, so that in large works such as those here considered, where the amount of insurance may be near £300,000, the risks are divided among a large number of different companies, who in their turn sub insure their risks in other companies not primarily engaged. There is a tacit understanding between the companies that one surveyor may act for the whole of them in any one particular case, thus judiciously securing uniformity of action. But it unfortunately happened that the four lamps in question, which had been tried for some months at the works of the writer's firm, were lent by them, along with a dynamo and driving power, for the purpose of ascertaining how a certain cotton mill, which had the disadvantage that one corner of the bottom room was darkened by buildings outside, could be lighted so as to replace the missing daylight. The four lamps were placed in position and tested. The result was far beyond expectation. It was found that the cleanliness of the work, which is an essential requirement in cotton spinning, could be supervised to a degree hitherto unattainable by artificial light. The owners of the mill were then anxious to adopt this kind of lamp immediately; but they met with an absolute refusal from the insurance companies to allow any open arc lamp to work in a cotton mill. This led to the question of its further use in the ironworks of the writer's firm, and at first a blank refusal was received, without any reason being given; but correspondence of some months resulted in permission being at length granted to continue its employment under certain rigid conditions. These indeed were reasonable as regards the conducting area of the wires, the voltage, safety fuses, and other necessary precautions.

In order to see whether there could be any valid objection to its use in cotton mills, the author made a fairly complete series of experiments. The danger in cotton mills is supposed to be that the finest fibres or filaments are liable in the process of spinning to escape in a certain proportion, under the action of the draught caused by the moving parts, and being of much the same specific gravity as the air, they are easily carried by upward draught. When they reach any ironwork, either columns, beams, shafting, or gas pipes, they have a tendency, owing to the latent electricity always developed in textile fabrics, to attach themselves radially to the electric or magnetic centre; and as the carding-room air in a cotton mill is always more or less charged with these floating filaments, the insurance companies feared the result of combustion by contact with the open arc would be that the fire would be conducted to a dangerous quarter by the loose filaments adhering to wires, etc. This fear is found to be absolutely groundless. Repeated and extended experiments have in every case failed to show any indication of danger from such a cause. The fallacy of the insurance companies objection is rendered apparent by the fact that at the present time they allow open gas jets in all cotton mills. If there were any danger in an open arc lamp, there would surely be more in open gas jets, which of course are more numerous than arc lamps would be. Furthermore, the arc lamps have to be lowered every eight hours of work for the purpose of changing the carbons. The gas jets are turned off when not required, and lighted again when wanted; this may occur two or three times a day. But every time the electric lamp is lowered it is thoroughly well cleaned, which is especially easy, as it consists simply in wiping the wire and the inside of an enamelled reflector. To prove that the arc lamps cannot convey fire by contact with the cotton fibre, the author has let fall in the inverted reflector quantities of what is termed cotton fly, being the lightest and most inflammable part of cotton fibre; and as soon as the level of the arc was reached and the top fibres were ignited, the fire spread rapidly round the cone of the reflector and burnt downwards towards the bottom. When keeping the eye level with the top of the reflector, it was impossible to see anything escape over this level except the black tinder resulting from the combustion of the fibre or fly. With the true cotton itself, smouldering particles might be seen to the extent of from 4in. to 6in. above this level, but it was proved that these smouldering embers had no heat beyond that necessary to give them their colour, for they were not even capable of exploding gunpowder.

For the purpose of further elucidating the question of fire risk, the author visited a mill in Belgium, not far from Ghent, where very coarse numbers were spun, the cotton being of short fibre, and the amount of evaporation, as it is termed, of fly from the lower filaments was particularly great, the cotton used being of the poorest quality. Directly over the carding engines was an arc lamp of more than 1,200 c.p., and during four hours spent in watching and noting the effect of the lamp upon the fly, on not one single occasion was the slightest spark visible outside the reflector. Sometimes when the fly was unusually thick in the air, owing to a carding engine being brushed out, a slight corruscation could be perceived near the centre of the reflector, like the twinkling of a star, but this would only occur once now and then. Undoubtedly a certain amount of fly was consumed, because when the lamp was lowered for examination a residue was found in the bottom of the cone, composed of the very lightest tinder of cotton, but utterly uninflammable under any circumstances. In this country the insurance companies declined to countenance any experiments, on the ground that mill owners had been satisfied up to that time with the ordinary gaslight and with their insurance regulations, and therefore they could see no good reason for a revolution of ideas. Furthermore, the definite allegation was made that on two occasions fires had been caused in cotton mills abroad which were lighted with arc lamps. Feeling the importance of ascertaining what amount of truth there was in this statement, the author wrote to the proprietor, manager, and others interested in each instance. In the first it transpired that not a cotton mill but a cotton store had been burnt, which was lighted not by arc lamps but by incandescent lamps only, and the theory to account for the conflagration was that of spontaneous combustion, which is by no means rare when cotton is stored in bulk. In the second instance the lighting was not by the open arc lamp inside an inverted conical reflector, but by an ordinary arc lamp surrounded with a glass globe. There was an aperture in the bottom of the lamp, and owing to some disarrangement of the clockwork regulating the carbons, a portion of an incandescent carbon had been split off, and falling through the aperture upon a mass of cotton beneath had set it on fire. When cotton in a loose condition does get on fire it is much like a train of gunpowder, and this mill, which was kept in a condition far from clean, being covered with a thickness of fly steeped in oil over the floor, walls, and ceiling, became so suddenly a mass of flame that the workpeople had considerable difficulty in making their exit from the burning building.

Inverted Arc Lamp.

Arc Lamp.—The complete absence of danger from the arc lamp used by the author will be more thoroughly appreciated from a description of its construction. It consists of two carbons of different diameters, the upper or negative carbon being solid, and the lower or positive carbon being annular and rather larger in diameter. Their areas are 0 200 and 0 486 square inch respectively, which proportion ensures their both consuming at the same speed, thereby avoiding the necessity of any complicated clockwork arrangement to differentiate the speed of the feed. In this lamp indeed there is no clockwork, but the carbons are drawn together by a pulley, string, and counterweight, their distance apart being regulated in the usual way by a magnetic brake. The pulley, weight, and brake are all contained in a cylindrical box attached to the underside of the cone of the reflector; and the only interruption to the light above is that occasioned by the thin arms forming the clip which holds the upper carbon. The crater carbon is here the lower one, in order that the large number of rays produced may be thrown upwards. The cone reflector is 25in. wide at the top and 7in. at the bottom, the angle of the cone being 88deg. The interior surface is ordinary white enamel upon the sheet-iron exterior. Each lamp is balanced by a counterweight over pulleys, and the counterweight hangs conveniently alongside either a wall or a pillar, so that it may not be in the way of traffic. Thus it is easy to lower the lamp for the purpose of renewing spent carbons, which has to be done

about every eight hours, and requires not more than one minute per lamp.

Practical Results of Working.—The plan of inverted arc lighting has now been in use in some portions of the writer's works for 12 and 13 hours a day during the last 12 months, and sometimes almost night and day, and the results of its working he has every reason to believe may be considered successful. The building, as already mentioned, consists of three storeys, each room 123ft. by 55ft.; the bottom room of all is surrounded to such an extent by other buildings that it was necessary to keep the gas burning the whole of the day. In this room the work consists of turning, fluting, polishing, and repairing what are known as fluted bottom rollers for spinning machines. These rollers require to be finished with mathematical accuracy, and the majority of them have to be channelled or fluted to the closeness of from 16 to 19 flutes per inch, the shape of the flutes being of the greatest importance. In the room above are manufactured top rollers to work on the fluted rollers, these also have to be mathematically correct, and their surface finished to a high degree of accuracy. In the third room are manufactured what are known as flyers, having one hollow leg, through which the cotton must pass down in a slightly twisted condition. Owing to the affinity of cotton fibre for metal affected electrically, however little, it is evident that any roughness of the interior surface of the hollow leg must be prejudicial to the working, and it is therefore necessary that the smoothness of finish should be unquestionable. The attic or roof room is used for the storage of patterns, as previously mentioned. In the bottom room there are 51 machines, consisting of lathes and fluting machines and others, and employing 60 workmen. The second room contains 164 machines, employing 139 workmen, and in the third room there are 69 machines and 112 workmen. Views were shown of two of the rooms, showing the position of the lamps that has been found to be most serviceable as the result of experiments. These views give an idea of the area lighted by each lamp, and also of the manner in which the reflected rays from one lamp cross and blend with the rays of the adjoining lamps. The only incandescent lamps used are those in the attic or pattern store, most of which are portable for the purpose of finding patterns on the various shelves; and also, strange though it may seem, two incandescent lamps in the bottom room for the examination and repair of slightly defective flutes. The latter lamps had to be applied because the reflected light from the arc lamps gives no shadow; and, in order to perceive the minute defects in the flute, it is necessary to have a light that will give a prolonged shadow, for the purpose of exaggerating what it is to be seen. The writer quite thought it would be possible to accomplish the same object by the use of a reflector; but the prejudices of the workpeople were too strong.

When first this mode of lighting the rooms was set going, and the gas turned off at the mains, there was much grumbling of the workmen, who protested it was impossible to perform their work by the new light. This difficulty, however, had been foreseen, and they were informed that as the light had been put in at a large expense for their comfort and health, they must at least give it a fair trial. Within six weeks of starting its regular working something occurred which prevented the requisite steam power from being furnished to the dynamo; and the gas therefore to be turned on again, exactly as it had been in the former time. The result was a deputation to the manager on the part of the workmen to know what they were to do, as they could not see how to perform their work by gaslight; and on one or two occasions since then, when the light has failed through one cause or another, the workpeople have declined to work with the gas, stating that they preferred to wait until the electric light was on again, and that they could pull up the time lost.

Dynamo and Lamps.—The dynamo is of Belgian construction, and known as the four-pole dynamo. It runs at 600 revolutions per minute, and gives a voltage of 115. It is driven by a countershaft from the main engine driving the machinery in the building, and with 60 arc lamps and 66 incandescent lamps it absorbs 70 h.p. The lights are steady and free from flicker; if ever a lamp is seen to flicker it may be certainly concluded that it has not been thoroughly cleaned, and that the carbon slides are sticking in the magnetic brake. Photographs are exhibited of each room at 10 o'clock at night in the winter; they were taken, of course, from the reflected light itself, and the exposure was in each case rather less than 10 minutes. Upon examination it will be seen that the detail is wonderfully distinct, even at the distance of 120ft.; this is particularly noticeable in the photograph of the bottom room. Attention must be called to the absence of shadows. It can be seen that there are no dark places on the floor, and that underneath the lathes and other machines, although directly below the reflected light, there is no such thing as a defined shadow.

Horwich Locomotive Works.—Four inverted arc lamps were tried by Mr. John A. F. Aspinall in one of the Lancashire and Yorkshire Railway workshops at Horwich, where, however, owing to the great height at which they had to be fixed, they *were not successful*. They have since been placed in the large drawing offices, and the light for drawing purposes is as perfect a light as can be. Failing on account of the height of the workshop to arrive at a satisfactory result with the solely reflected light, Mr. Aspinall has succeeded in lighting the main machine shop with ordinary open arc lamps, each protruding through a whitewashed disc formed of light boardings framed together. A curious combination is thereby produced of lighting by the reflected and the direct rays. It has not the whole of the advantages of the reflected light, because the eye has a tendency to glance upward towards the dazzling area, and shadows are projected. Nevertheless the writer is convinced that by this combination of reflection a gain has been achieved of at least 25 per cent. over the ordinary direct arc lighting without reflection, and all concerned are satisfied with the result.

Cost.—The question of cost of electric lighting, which after all is of the greatest importance, is somewhat difficult, and the writer is hardly in a position at present to give data sufficient to be of much practical value. Having regard to the number of workpeople who could be served with the light, the cost is less than that of gas, and of course the light is stronger and more general, so that in respect of candle power it would be considerably cheaper than gas. In the three-storey building at the author's works there were 502 gas jets, each burning four cubic feet per hour. Gas costing 2s. 8d. per 1,000 cubic feet would therefore come to something like 5s. 4d. per hour for this consumption. In the 60 electric lamps the only consumption is that of the carbons, which are reckoned at ½d. per lamp per hour. This has subsequently been reduced considerably, but taking this basis, the 60 lamps would together cost 2s. 6d. per hour for carbons. The 66 incandescent lamps which are included in the 70 h.p. absorbed by the dynamo would of course add to this cost, as they are only 1,000 hour lamps. The greatest cost after the original installation is depreciation and horse-power. Taking the whole into consideration, it is probable that the cost of electric lighting would be more than that of gas, but as the light is so much more satisfactory, it may prove an economy in most cases to adopt it. Thus, in the present instance the total candle power of the 500 gas jets would be roughly 8,500, while the arc and incandescent lamps combined would have 73,000 c.p., much of which, however, is of course useless except for the general effect of the light.

Conclusion.—The light now described has proved in practice to fulfil the requirements enumerated at the beginning of this paper as the necessary qualifications of a good artificial light, and for any class of manufacture for which it is applicable. For bleach and dye works, where it is necessary to distinguish minute difference in shades of colour, it must be invaluable, permitting this delicate work to be carried on in the dull winter days, which is now difficult, if not impossible. If the insurance companies can be persuaded that not only is there no danger from this light, but that it is perhaps safer than any other mode of lighting, there seems every possibility that the use of the arc lamp will undergo a rapid development.

BRIGHTON AND HOVE COMPANY.

PROPOSED SCHEME OF RECONSTRUCTION.

The following circular has been issued by the Brighton and Hove Electric Light Company:

In accordance with the suggestions made at the meeting of Debenture-holders' and Creditors' Committee that a scheme for the reconstruction of the company should be formulated, the following is submitted for your consideration and approval:

1. The subscribed capital and liabilities of the present company are as follows:

Ordinary shares of £5 each	£15 005
First mortgage debentures	15,000
Unsecured liabilities (about)	8,500
Total	£38,505

2. The basis of the reconstruction proposed is as follows: (*a*) Present shareholders, £15,005: To submit to the reduction of the present £15 005 ordinary shares to £7,505, entitling the holders to any profits after providing for interest on debentures and dividends on the two proposed classes of preference shares. (*b*) Creditors on unsecured accounts, about £8,500: To be allotted second preference shares to the value of their claim on outstanding accounts, entitling holders to a 6 per cent. dividend after providing interest on debentures and for dividend on first preference shares, and to rank in priority to the ordinary shares as regards capital. (*c*) Debenture holders, £15,000: To surrender half their holding in debenture bonds, viz., £7,500, and to receive in exchange £7,500 in first preference shares, in addition to shares for arrears of interest entitling holders to a dividend at the rate of 6 per cent. per annum after payment of interest on debentures, and to rank in priority to the second preference and ordinary shares as regards capital. (*d*) New subscribers, £5,000: To subscribe £5,000 new capital on prior lien debenture bonds, bearing interest at the rate of 6 per cent. per annum, such prior lien

debentures to rank as a first charge on the property and undertaking of the company in priority to the £7,500 debentures retained by the present debenture bondholders.

3. The following is a statement showing the subscribed capital of the company under the proposed reconstruction scheme:

Ordinary shares—1,501 shares of £5 each	£7,505
First preference shares—8,500 shares of £1 each	8,500
Second preference shares—8,500 shares of £1 each	8,500
Total share capital	£24,505
Debentures—75 debenture bonds of £100 each, £7,500; and 50 prior lien debenture bonds of £100 each, £5 000	12,500
Total share and debenture capital	£37,005

4. Under the above scheme a sum of £5 000 capital is proposed to be raised by prior lien debenture bonds to enable the company to extend its business and to carry out some important alterations to the plant and overhead circuits. The new money will be prudently dealt with and will only be applied to the extension of the business where there is a prospect of a remunerative return.

5. The present debenture holders retain to the extent of one half their present debenture bonds subject to the £5 000 prior lien bonds proposed to be raised. They surrender the remaining one half of their debentures for 6 per cent first preference shares, which shares will be preferential as regards interest and capital so that the debenture-holders under the reconstruction scheme will stand in very much the same position as they do to-day, but will be relieved from the possibility of the present creditors of the company causing a forced realisation.

6. The unsecured creditors in discharge of their debts receive second preference shares entitling them to a 6 per cent dividend after the interest on debentures and dividends on the first preference shares have been paid, and to have priority as regards capital over the ordinary shares, but to rank behind the first preference shares. Debts under £1 to be paid in cash

7. The present ordinary shareholders will submit to a reduction of 50 per cent. of their present holding in the reconstructed company, which shares will be entitled to any surplus profits after payment of interest on debentures and dividends on the proposed two classes of preference shares.

8. By the plan proposed the business will be continued as a going concern. The present company has suffered from too small a capital for so quickly an increasing business, and its present difficulties have therefore necessitated the appointment of a receiver and manager on behalf of the debenture holders for the purpose of protecting the interest of all parties. This has necessarily, for the present, impeded the progress of the business and the obtaining of additional customers; but should the proposed reconstruction be carried out and the company thereby placed on a sound footing, it would be fair to anticipate that the business would be an increasing one. In this view accounts have been laid before the directors by the secretary and manager, and from a careful estimate of the probable revenue and working expenses it is expected that, on the basis of a moderate increase in the output of current, and when the full capacity of the plant is taken up, the net profit should be quite £2 000 a year, whereas the interest charges named above would amount to £750 and the dividends on the preference shares to £1,020, or a total of £1,770

9. The growth of the company's business in the past is shown by the following comparative statements:

STATEMENT OF LAMPS CONNECTED TO MAINS.
(On the basis of 32 watts per 8 c p. lamp)

	1891.	1892.	1893
January	6,426	9,618	15,563
February	6,570	9 873	15,624
March	6 688	10 320	15 824
April	6,953	10 531	16 027
May	7,061	10,005	16,195
June	7,170	10,625	15,971
July	7,588	11,310	16,202
August	7,948	12,898	16,294
September	8,168	14,713	16,478
October	8,420	14 977	—
November	9,041	15 541	—
December	9,498	14,868	—

STATEMENT OF ELECTRICITY REGISTERED BY THE CONSUMERS' METERS.

	1891.	1892.	1893.
January	12.602 units	16,535 units	28 072 units.
February	9,110 ,,	13,603 ,,	21,672 ,,
March	8,087 ,,	10,707 ,,	19 061 ,,
April	5,875 ,,	8,400 ,,	11,809 ,,
May	4,594 ,,	4,911 ,,	8,990 ,,
June	2,938 ,,	3 727 ,,	8,246 ,,
July	4,402 ,,	5,172 ,,	9,576 ,,
August	4,401 ,,	8 290 ,,	11,009 ,,
September	6,707 ,,	12 500 ,,	16,405 ,,
October	13,769 ,,	18,796 ,,	—
November	16,678 ,,	26,818 ,,	—
December	18,630 ,,	31,652 ,,	

10 It is proposed that the directors of the reconstructed company should, if possible, be elected from local shareholders and debenture holders, so as to give the control of the company to gentlemen resident in Brighton and the immediate neighbourhood, and the formation of the Board is proposed to be constituted of the following directors: By the ordinary shareholders, one; by the first preference shareholders, one; by the second preference shareholders, one; by the debenture-holders, one; by the subscribers of the prior lien bonds, one: total directors, five.

BUSINESS NOTES.

Hull.—Messrs. King and Co. are installing the electric light in the workhouse.

Telephony.—The National Telephone Company are extending operations at Cardiff.

Western and Brazilian Telegraph Company.—The receipts for the week ended October 20 were £3,493.

Bristol.—The Sanitary Authority have resolved to place a refuge and an electric lamp on the west side of St. Augustine's Bridge.

Siemens and Halske Lamps.—Messrs Siemens Bros. and Co. are making preparations to sell Siemens and Halske incandescent lamps at 1s. 6d.

The Guildhall.—The Court of Common Council have resolved to light the Art Gallery of the Guildhall by electricity at a cost of installation of £290.

Change of Address.—The address of Woodhouse and Rawson United, Limited, in Glasgow will be 12, West Campbell-street, after the 11th proximo

Indo-European Telegraph Company.—A half-yearly interim dividend at the rate of 5 per cent. per annum has been declared, payable on November 1.

Glasgow.—Messrs J. Buchanan and Co, Glasgow, have just finished a new brougham built to the design of Sir W. Renny Watson. It is lighted by electricity.

Newcastle.—Messrs Charleton and Co., of Newcastle, have supplied the fittings for the electric lighting of the first-class refreshment-room at the central railway station.

Preston.—The Electric Lighting Committee of the Town Council have held two conferences with representatives of electrical firms on the subject of illuminating the town with electric light.

Chelsea Town Hall Lighting.—The Hall Committee and the Electric Lighting Committee of the Vestry are to again consider and report as to the advisability of lighting the Town Hall with electricity.

Callender's Bitumen Telegraph Company.—The Directors of Callender's Bitumen, Telegraph, and Waterproof Company, Limited, have declared an interim dividend, payable on 1st prox, at the rate of 10s per share.

Gloucester.—The Gloucestershire Standing Joint Committee have adopted agreements for telephonic communication to be established between certain police stations near Bristol and the Bristol telephonic exchange.

Paddington.—The Paddington Baths Commissioners have accepted the tender of Messrs. Dawson and Hammond, of John street, Edgware road, for fixing electric lighting apparatus in front of the platform in the large hall.

The "Hard" Incandescent Lamp.—The "Hard" Incandescence Lamp Company, of Zurich, have appointed as their representatives in this country Messrs Wilhelm and Co, of 132, Wool Exchange, E.C., who will shortly place the lamps on the market.

Dewsbury.—The Local Government Board have written to the Board of Guardians asking for further particulars in respect to the proposal of the Board to expend £2,100 upon the necessary works and plant required for electric lighting purposes.

Monte Video Telephone Company.—The accounts for the year ended July 31 last show an available balance, including £1,879 brought forward, of £8,775. From this amount it is proposed to place £5,000 to reserve, and £3 000 to depreciation fund, carrying forward the balance of £775.

Glasgow.—It is expected that by the middle of November the whole of the Trongate and Argyll street, from Glasgow cross to Anderston cross, will be lit by electricity. In this thoroughfare the lamps are being placed 45 yards apart, as compared with 60 yards in Sauchiehall street.

City and South London Railway Company.—The receipts for the week ending October 22 were £807, against £865 for the same period last year, or a decrease of £58. The total receipts for the second half year of 1893 show an increase of £298 over those for the corresponding period of 1892.

Llandrindod Wells.—At a meeting last week of the Local Board, the clerk read a number of letters containing particulars as to electric lighting, and it was stated that an electrical engineer was willing to attend the Board and explain the system free of cost. It was agreed to hold a special meeting for that purpose.

Personal.—Mr Hylton Spagnoletti has been appointed agent for Messrs. J. B. Saunders and Co, of Cardiff, in Swansea and district for electric light installations and private telephone work. Mr Joseph A. Jeckell, recently works manager of the International Okonite Company, has been appointed electrical engineer to the Town Council of South Shields.

Poplar.—At the meeting of the Board of Works Mr. Cooper, C.E., wrote with reference to the Poplar Electric Act, stating that his clients, the Poplar Electric Lighting Supply Company, were willing to take a transfer of the powers granted to the Board on the usual conditions, with the option of purchasing the undertaking at reasonable notice. This was referred to committee.

Yeadon.—The Local Board have given instructions to the clerk to make application to the Local Government Board for a provisional order for power to light the township by electricity. It was also decided to make application for sanction to borrow £7,000 for such purpose. The "compulsory" area for lighting purposes was decided upon, the extreme ends of the township being left out.

Aberdeen.—The report of the members of the deputation with regard to the Aberdeen Beach will be laid before a meeting of the Links and Parks Committee. The scheme which the deputation recommend involves an expenditure of between £40,000 and £50,000. In addition to a proposed electric tramway suggestions are made for the construction of an esplanade from the Beach Battery.

Newcastle.—The Swan Edison Company have secured premises in this town. The company had the other night some scores of their incandescent lamps illuminated in their windows, several of the lamps were of the fairy coloured kind, and the effect, with the warm glow of coloured windows above, and with the united dazzle of silver and electricity in the large jewellery establishment below, was beautiful.

Hamilton.—The Police Commissioners, as the Local Authority, have held a meeting to consider whether it is advisable to give approval to an application by the Caledonian Electric Supply Company, Limited, to the Board of Trade for a provisional order to authorise them to supply electricity within the municipal boundaries or whether the Local Authority should themselves apply. After consideration the latter course was unanimously adopted.

Tenders for Gateshead.—The Gateshead Industrial Co-operative Society, Limited, invite tenders for a complete installation of the electric light for their Whitehall road branch, Gateshead. Specifications can be had from the secretary on a deposit of one guinea being made, which will be returned on receipt of a *bonâ fide* tender. Sealed tenders to be sent in to the committee, Gateshead Industrial Co-operative Society, Limited, Jackson street, Gateshead, by 4 p.m. on 30th inst.

Meeting of Creditors.—A meeting of the creditors of Wm. Andrews was held last week at Nottingham. The bankrupt is an electrician of the St. Ann's Valley, lately trading and residing at 118, Hungerhill road, Nottingham. Liabilities were stated at £495. 18s. 10d., and the assets at £423. 8s., leaving a deficiency of £72. 10s. 10d. The creditors present were Mr. A. W. West, Mr. W. H. Parker, Mr. Thos. Leman, and Mr. T. F. Walker. The public examination is fixed for November 3.

Wolverhampton.—The gas company's Act, having received the Royal assent, states that additional lands are to be acquired and gasworks erected thereon, subject to the proviso that the company shall not, without the written consent of the Electric Construction Corporation, Limited, manufacture on their present works, or on the selected lands, any chlorine compounds or any sulphuric acid, "except to such an extent (if any) as is produced by or in the manufacture of gas, according to the ordinary methods in use in such manufacture."

Clerkenwell.—At the meeting of the Vestry a letter was received from Mr. E. Garcke, director of the County of London Electric Lighting Company, asking the Vestry to rescind their decision refusing consent to an extension of time for carrying out their order, and stating that they are assured the work would be commenced in January or February next. Mr. J. Walton, in moving that the Vestry adhere to their decision, said they did not say they would not reconsider when their hands were untied. Mr. J. Johnson seconded the resolution, which was carried.

Trade Dispute.—A young man named Albert M'Queen was remanded on Tuesday by Mr. Headlam, the Manchester City stipendiary, on a charge of doing wilful damage. On the 20th inst. workmen were laying down an electric light installation at the Mosley Hotel, Piccadilly. A dispute occurred amongst them, and in the course of it prisoner, who had been discharged, is alleged to have torn away the fuse attached to the Corporation main supply, with the result that the hotel, which had been temporarily lighted up, was thrown in complete darkness. The fuses on the staircases leading from the basement were also severed.

Blackpool.—The electric lighting plant has attracted the attention of several corporations who are considering the advisability of introducing a municipal supply. Messrs. T. Challoner and Son have dissolved partnership with Messrs. Lowcock and Hill in their electrical branch, and are now on their own account supplying all necessary electrical apparatus, and fitting up installations, etc. The firm fitted up the electric light in the Clifton Hotel dining-room in six hours, under the personal supervision of Mr. W. Challoner. The same firm have orders from Mr. W. C. Richardson, Central Beach; Mr. H. Bentley, Church street; Mr. J. S. Todd, Talbot-square, and several others.

Bradford.—The annual abstract of accounts of the Bradford Corporation for the year ended March 31, 1893, has just been issued by the borough accountant (Mr. G. A. Thorpe). In the electricity department the income from this source was £8,399, and the expenditure £3,913. This shows a profit on trading account of £4,486. Against this is set sinking fund and interest charges, amounting to £2,863, leaving a net profit of £1,623 for the year. Up to the beginning of the past year the working of the department had resulted in a net loss of £351, which deducted from the present year's net profit of £1,623 leaves an amount of £1,289, which may be appropriated as the Council deem advisable.

Leeds.—Writing to a Leeds paper, Mr. W. S. Graff Baker says: "*Referring to your account of a meeting* held in support of Mr. Peter Laycock as a candidate for the north-east ward, held at Burmantofts on Wednesday, the 18th inst., I see it reported that Mr. Laycock, in addressing the meeting, stated that 'Mr. Graff-Baker got into difficulties; he had the plant on the hire system from Thomson-Houston, and that when demanded the money he could not pay it. The result was that Thomson-Houston could claim the tramcars and everything in connection with Mr. Graff-Baker's estate.' As this statement is absolutely false, and calculated to reflect upon my credit, I must ask you to give publicity to this letter. I have instructed my solicitor to write to Mr. Laycock, and secure from him a public apology for such utterance."

Tenders Wanted for Derby.—Tenders are invited for the wiring, provision, and fixing of the electric light fittings, the alterations to existing gas fittings where required, and the accessories of the whole or any of these for the electric lighting of the institution for the Chairman and Board of Management of the Midland Deaf and Dumb Institution, Friar gate, Derby. Copy of the specification and forms of tender may be obtained from Messrs. Bramwell and Harris, engineers, 5, Great George street, Westminster, S.W., or from Mr. J. E. Stewart, resident engineer, at the Corporation Electric Lighting Station, Silk Mill lane, Derby, on deposit of two guineas, which will be returned on receipt of a *bonâ fide* tender. Tenders to be addressed to the chairman of the Board of Management, and delivered at the institution by November 6.

Bath.—At a meeting of the Surveying Committee a letter was read from Mr. John Stone (town clerk) stating that he had been instructed by the Watch Committee to complain of the electric light being switched off too early in the morning. Mr. Moore said that the time table of lighting which it was recently decided to adopt on trial was manifestly wrong, as the light was switched on too early, when it was light, and off too early in the morning, when it was dark. Mr. Sturgess had undertaken to see the manager of the company upon the point. The question was referred to the Lighting Committee. Subsequently the usual report was read respecting the electric light, which contained reference to an unusual mention of instances of defective lighting. Mr. Mitchell said it was about the worst record they had had. Bills amounting to £1,553 were passed. This included the quarter's electric light account, from which £8. 15s. had been deducted as fees.

Tenders Wanted for Sunderland.—The Corporation invite tenders for carrying out the work comprised in any or all of the following contracts: (1) Lancashire boilers. (2) High speed compound engines, dynamos, pumps, steam and other pipes, etc. (3) Motor alternators, switchboard, etc. (4) Main switchboard, instruments, and connections. (5) Batteries. (6) Insulated cables, etc. (7) Roadwork (*a*) construction of culverts, laying of cast-iron pipes and casings, and building service boxes; (*b*) supply of cast-iron pipes, casings, and service box frames and covers; (*c*) supply of stoneware casings and insulators. (8) Copper strip. (9) Gunmetal grip boxes. Those desirous of tendering for any of the above contracts must send in their names and addresses to the borough engineer, Town Hall, Sunderland, and copies of drawings, specification, and form of tender will be forwarded to them on receipt of cheque or order for £2. 2s., which will, however, be returned on their submitting a *bonâ fide* tender.

Edinburgh.—At a meeting of the Cleaning and Lighting Committee, the proposed lighting of the chief streets by electricity was under discussion. It appears that the matter had to be taken up somewhat hurriedly, and a recommendation arrived at, as the Board of Trade require to be informed forthwith of the intentions of the Corporation in regard to street-lighting before they give sanction to the general scheme. It was accordingly resolved to recommend to the Town Council that various streets should be lighted by electricity. The lights will be arc lamps. It was stated that each electric lamp in London cost £27 a year, but it was hoped that the Edinburgh lighting would be effected at a less cost. The Electric Lighting Committee of the Town Council have resolved to take power to shut up St. Cuthbert's-lane in that part formed by the triangle of St. Cuthbert's-lane, Dewar-place, and Torphichen-street. This step is necessitated by the contemplated electric lighting depôt.

Whitehaven.—The Whitehaven Trustees have decided to extend the area of supply of electricity for private lighting by laying a cable from the junction of Lowther street and Scotch-street, along Scotch street, Irish street, James street, Swingpump-lane, and Quay street. The private connections so far number about 30, and the Trustees have in hand several other applications, including those of Mr. T. Bowman and Messrs. Pattinson and Winter. Mr. Bowman's branch shop in Lowther street is already lighted by electricity, and the fact that he is desirous of having his extensive premises in the Market place also fitted up with the necessary apparatus for electric lighting says something for the success of the new system of illumination. Messrs. Pattinson and Winter intend having their flour mill at the old barracks lighted by electricity. The lighting of the harbour by electricity is expected to be completed shortly. Already the south side and the north wall are lit up with the new illuminant, and the remaining portions will be similarly lighted as soon as the fittings arrive for the larger lamps.

Eastern Extension, Australasia, and China Telegraph Company.—The report for the half year ended June 30 says the gross receipts, including Government subsidies, amounted during that period to £257,986. 13s. 5d., against £246,988. 16s. 6d. for the corresponding half year of 1892. The working expenses, including £21,649. 3s. 3d., for cost of repairs to cables and expenses of ships, absorb £78,229. 19s. 3d., against £79,281. 11s. 10d. for the corresponding period of 1892, leaving a balance of £179,756. 14s. 2d.

From this is deducted £3,968. 15s. 5d. for income tax, £32,171. 1s. 1d. for interest on debentures, contribution to sinking fund, and special expenditure, leaving £143,616 17s. 8d. as the net profit for the half year. Two quarterly interim dividends of 1¼ per cent. each, amounting to £62,500, have been paid for the half-year under review, leaving £81,116 17s 8d. to be carried forward. The working of the Australian tariff arrangement for the second year of guarantee, ended April 30 last, has resulted in a loss of £43,558, as compared with £55,040 for the first year, and, in accordance with the terms of the agreement, one half of the loss, or £21,779, has been made up by the guaranteeing colonies and the other half borne by the associated companies.

Tenders for Newport (Mon.).—The Electric Lighting Sub-Committee of the Corporation of Newport invite tenders for the supply and erection of steam boilers, feed water heaters, economiser, pumps, mechanical stokers, forced draught apparatus, steam, exhaust, and water pipes, condenser, tanks, steam engines, driving ropes, oil filter, alternators for incandescent lighting, dynamos for arc lighting, switchboards, instruments, arc lamps and lampposts, cables, culverts, surface boxes, junction boxes, converters, converter boxes, converter cases, switches, fuses, meters; also day load plant to consist of semi portable engine, alternator and exciter, and switchboard for the equipment of the municipal electricity works of the county borough. The plan of buildings, map, and specification, with terms and conditions of tender and contract, may be obtained at the offices of Mr. Robert Hammond, M I E E., the consulting engineer to the Corporation, 117, Bishopsgate street, London, E C, on and after the 30th inst, on payment of £2 2s., which sum will be returned on receipt of a *bonâ fide* tender. Tenders (sealed, and marked "Tender for Electric Lighting") must be addressed to Mr. Albert A. Newman, the town clerk, at the Town Hall, and be delivered on or before Monday November 20

Dundee.—The completion of the work of introducing the electric light into the joint premises of Messrs Frain and Son and the Edison Swan Electric Company in Castle street is of special interest in connection with the growing popularity of the new illuminant in Dundee The establishment of a branch depôt in the city under the superintendence of Mr William Frain, jun, is intended to meet the convenience of electrical engineers in the East of Scotland. In the installation which has just been introduced the current is derived from the public supply, and the illumination of the entire establishment is controlled from an Ediswan switchboard The fittings in the Edison Swan Company's room, over a hundred of which can be lit up, comprise almost every conceivable variety, and when the full electric current is turned on the effect is beautiful. The company show electric motors of such powers as half and quarter horse, suitable for driving butchers' mincing machines, sewing machines, etc, also voltmeters and ammeters. The installation in the premises of Messrs Frain and Son includes electroliers in each of the windows, and an artistic arrangement of pendants in the saloon. The work of fitting up the whole installation, it should be added, has been carried out by Messrs Maxwell and Son, King's-road, Dundee.

Halifax.—The minutes of the Gas and Electric Lighting Committee presented at a meeting of the Town Council last week, stated that a letter had been received from Mr T England, solicitor, on behalf of the Halifax Mutual Electric Light and Power Company, offering, in consideration of the Corporation paying them £2,000, to guarantee a supply of the light for 12 months, or, as an alternative offer, that the company would accept £4,000 for their plant, the Corporation taking over the same at once The minutes further stated that a deputation had waited upon the committee from the users of the electric light in the district asking the Corporation to endeavour to come to some arrangement in order that the power for supplying the light may be continued as heretofore. A sub committee, consisting of the Mayor, Aldermen Brook and Patchett, and Mr. Thomas Greenwood, had considered the offers and, acting on their report, the committee decided to reject them. Upon the minutes coming up for confirmation, Alderman Tattersall asked what arrangements were being made towards supplying the electric light to the consumers represented by the deputation. The Mayor said the committee had considered the matter, and had come to the conclusion that they could not use the ratepayers' money in the way indicated. Mr. J. Turner Spencer asked if there was any likelihood of some arrangement being made for continuing the electric light before the date when the supply was to be discontinued The Mayor said he did not for one moment think that the committee could make any arrangement. They could not use the ratepayers' money in that way The minutes were confirmed.

Disposal of House Refuse.—Writing to a Cardiff paper, "S C" says: "At a recent meeting of the Parliamentary Committee Alderman Jacobs very opportunely referred to the subject of the disposal of house refuse. It is admitted that burning is the least costly method of disposing of refuse, even when the heat generated is wasted. But by the adoption of efficient generators (not destructors, please), of which several types are being experimented upon and the interposition of steam boilers between the furnace and the chimney, a large amount of heat may be utilised. Heat is money, as our electrical friends only too well know and as most of us feel, and this process of converting ashbin refuse into mechanical energy may be applied to electrical installations with advantage, for the reason that the demand for the power will be absolutely constant. and the best results from destructor cells, as now designed, can only be attained by regular and uniform working. The by products of our domestic economy need be no longer a costly nuisance, but, on the contrary, a source of relief to our ever-increasing burdens. At Oldham and at Warrington recent experiments have shown that the burning of one ton and a half of house refuse per hour has generated gases of over 2,000deg. of heat, which, in passing through a multitubular boiler, 7ft in diameter and 12ft. long, developed 50 h p. per hour. Experts admitted that by the use of better appliances (larger heating surface and more efficient draught, such as a tall chimney stack (the experiments were made with a steam jet)) a much larger evaporation would be attained, probably equal to 90 h.p. or 100 h p., which works out something like 40lb of refuse per horse-power per hour These figures may not be exact; they are taken from notes culled from reports of proceedings This source of heat energy brings the cost of steam power down to the level of water power, which must mean the opening up of a fine field for the operations of electrical engineers, whose sole obstacle, apparently, to illimitable progress and unbounded utility is the cost of power to supply electrical energy to batteries for electrical motors and for haulage of tram and other vehicles, and for lighting, heating, and cooking, and kindred purposes."

Lighting at Camberwell.—As mentioned in previous issues, Mr. Manville was appointed some time ago by the General Purposes Committee of the Camberwell Vestry to report as to the best means of introducing a supply of electricity into the parish. The report having been presented and read, it was resolved that it should form the basis of a lecture This was delivered at the vestry hall on the 20th inst The lecturer, after dwelling upon the progress of electric lighting throughout the United Kingdom, pointed out that an electricity supply undertaking, so far from meaning an addition to the rates, was likely to prove a source of profit to the ratepayers The capital borrowed on the security of the rates was repayable in a period of not less than 30 years, and so long as the revenue derived from the sale of electricity left sufficient profit after the expenses of maintenance were provided for, both the capital and the interest upon the loan were paid without the smallest charge being made upon the rates, and at the end of a period of 30 years the ratepayers owned a valuable undertaking which had cost them nothing Speaking of profits, the lecturer stated that in the case of Bradford at the end of last half-year the profit was estimated at upwards of £3,000 In St Pancras the result of the first year's working was so satisfactory, and the demand for electricity so great, that they were now engaged in extending their works by the expenditure of another large sum. At the Dublin station erected under Mr Manville's advice at the end of the first half year of working, March 28th this year, a net profit of £862 had been made, being almost sufficient to pay the interest on the loan of £38 000 and the sinking fund, and it was known that at the end of the first year's working there will be a surplus after the interest and the sinking fund for the whole year have been paid, and a further sum of £24,000 had been applied for to extend the works. The utilisation of dust destructors was next adverted to. By this means not only could the dustbin refuse of the Vestry be got rid of, but a reduction of at least 15 per cent could be made in the production of electricity. By means of slides a large number of electricity supply stations were illustrated The room was lit by means of high candle power and various incandescent lamps kindly exhibited by the Edison Swan Company. The system of arc lighting and the use of electric motors were illustrated by means of apparatus lent by Messrs. J. G Statter and Co Various experiments were also shown, and a large and most interesting exhibition of cooking and heating by electricity, including ovens, grillers, kettles, curling-tongs, frypans, radiators, etc., in actual work was shown by the kindness of Messrs. R E Crompton and Co At the close of the lecture it was proposed that Mr Manville be requested to repeat the lecture in a larger hall, so that a larger number of the ratepayers might attend.

Barnet.—With reference to the note given in our last issue, the clerk to the Local Board mentioned at a meeting of the authority last week that he had written to the Electrical Installation Company requesting a representative to attend before the Board, but he had received a telegram to say that they could not attend that night. A representative of the company had, however, come down, and was waiting to see the Board. The Board then decided to see the representative. Mr Cooper, one of the engineers of the Electrical Installation Company, 64, Victoria street, then entered the room. He said some three months back he brought the question of electric lighting before his company, and when he mentioned Barnet they seemed very much disposed to apply for powers to light the district The company understood the Board had obtained a provisional order, and when he came down to view the district he made enquiries and understood that the power to light might be given to some company willing to give a proper scheme They were willing to submit a scheme, but they did not know what were the views of the Board. He thought that the town could be well lighted by the low-tension system, which could be carried out and afford sufficient light in an area comprising three miles from the station. With regard to private lighting, they would give private persons the option of installing the wires at their own cost, or renting the wires from the company, or taking the light at a certain price, including wire and fitting up. It was also thought that some amount of revenue would accrue to the Board, because for every 100 lights a certain amount of money would be devoted to public lighting, which his company thought would be an incentive to private lighting. The price per unit would be 8d. per unit at first, but as the scheme increased the price would be reduced They might be able to supply the light at 7d per unit. The public streets would be lighted with arc lamps of 1,500 c p The street lighting would be in two circuits, and the prices for public lighting would depend upon the difficulties encountered in excavating and other

matters, but he could not say exactly what the price per lamp would be. The company would take the provisional order on the terms and arrangements proposed by the Board. The provisional order was for 42 years with option for the Board to let it on lease at 7, 14, or 21 years. In reply to Mr. Morse Mr Cooper said that not less than £6,000 would be required for preliminary expenses. His company would put a plant down with underground mains twice as large as was required for Barnet. Mr Cooper having retired, Mr Walker moved the following motion, of which he had given notice: "That the Board take steps to light their district with electric light at the expiration of the present gas contract, and to supply private consumers under their provisional order." He said the present mode of lighting was not only bad but costly, and mentioned figures showing that the town had lost during the last 20 years nearly £1,000 a year through the lighting not being in their own hands. He had a petition signed by 50 of the largest consumers of gas, whose gas accounts varied from £20 to £50 per annum, asking the Board to light the district with electric light, and those consumers represented £1,200 a year gas rental. He proposed that the public streets should be lighted by 56 high tension lamps placed 80 yards apart, which would cover the district and give a light of 1,000 nominal candle power, which would give a light four times better than they had at a cost of £400 a year, or, roughly speaking, £100 less than for gas. If a contractor took it in hand it would probably cost £700. The private lighting would be low tension, and if they had 3,000 8 c.p. lights at 7d. per unit that would produce £2,100, or an income of £2,500. The figures would then be as follows: Capital invested, £10,000, interest at 3½ per cent., £350 per annum; repayment of capital and depreciation, £550 per annum; salaries, £230 per annum; coal and renewal of lamps, etc., £1,000 per annum; contingencies, £100 per annum—total expenditure, £2,230; income, £2,500, which, as the Board would see, left a surplus. He had asked the Board to use the order themselves, as they would do it cheaper, but he was content to have the matter referred to a committee. Mr. Clark said he would second the motion, because it was time they had some alteration in lighting matters. Mr Widdicombe said the subject of Mr. Walker's resolution should be referred to a committee, and he would move that it be referred to a committee "To enquire first whether it is desirable to light the town with the electric light; secondly, if so, whether it is desirable that the Board should undertake the work itself; and, thirdly, whether the provisional order should be leased to a company. That the committee consist of Messrs. Walker, Morse, Fison, Schmidt, Clark, and Drayson." Mr Martin Pooley seconded the amendment, which, with the following addition, "That the committee have power to insert advertisements in such papers as may be deemed advisable for offers to take the transfer of the provisional order, and to consider replies and report thereon from time to time," was carried.

PROVISIONAL PATENTS, 1893.

OCTOBER 16.

19378. **Improvements in electrical cooking and heating apparatus.** Gustav Binswanger, 71, Queen Victoria-street, London.

19410. **Improvements in electrical fittings, also applicable to other purposes.** Arthur Firth and George Yate Ashwell, 15, Abbey-street, Greenheys, Manchester. (Complete specification.)

19418. **Improvements in the manufacture of wire ropes, electric, and other cables.** John Thomas Williams and George James May, 12, Basinghall street, London.

19423. **Improved continuous electric current distributing system.** Michael von Dolivo Dobrowolsky and "Allgemeine Elektricitats-Gesellschaft," 47, Lincoln's-inn fields, London. (Complete specification.)

19427. **Improvements in electromotor toys.** Richard Myers, William Berwell, and William Albert Griffiths, 323, High Holborn, London.

OCTOBER 17.

19465. **Improvements in systems of electric distribution.** Charles Arthur Allison, 52, Chancery lane, London. (Cyprien Odilon Mailloux and William S. Barstow, United States.)

19515. **The applicati n of tinsel cord in the manufacture of candle shades, electric light shades, and candle sockets.** Emil Guttentag, 12, Bramfield-road, Wandsworth Common, London.

19529. **Improvements in automatic central telephone switch apparatus.** Franz Nissl, 28, Southampton buildings, Chancery lane, London. (Complete specification.)

19534. **Improvements in and relating to electric light switches and wall plugs.** George Davis, 22, Glasshouse street, Regent street, London. (Complete specification.)

19542. **Improvements in apparatus for the electrolytical decomposition of salt solutions.** Carl Kellner, 46, Lincoln's inn fields, London.

OCTOBER 18.

19599. **An improved shade for oil gas, electric, or other lights.** James Frederick Hoyne and George Robert Stoddart, 52, Chancery-lane, London.

19614. **An improvement in secondary battery plates.** William Jeffery, 39, Beckton road, Barking-road, London.

19625. **Improvements in glass bulbs for electric lamps.** Mildred Williams, 26, Budge-row, Cannon street, London.

OCTOBER 19.

19676. **A new electric arc lamp.** Emmanuel Torrini, 46, Hall-street, London.

19688. **Improvements in safety appliances to be used in connection with electrical decomposing apparatus.** James Charles Richardson, 6, Bream's-buildings, Chancery-lane, London.

OCTOBER 20.

19759. **Improvements in dynamo machines.** Frederick William Lanchester, 18, Southampton buildings, Chancery lane, London.

19765. **Improvements in electric switches.** John Leslie Durward, 323, High Holborn, London.

19784. **Improvements relating to the manufacture of incandescent electric lamps, and in apparatus to be used therefor.** Charles John Peach Robertson, 6, Bream's buildings, Chancery lane, London.

19789. **Improvements in electric railways.** Sydney Pitt, 24, Southampton buildings, Chancery lane, London. (The Universal Electric Company, United States.) (Complete specification.)

19791. **Improvements in or connected with electrolytic cells.** Ferdinand Hurter, Henry Auer, and Edmund Knowles Muspratt, 47, Lincoln's inn fields, London.

19809. **Improvements in carbons for electrodes and other purposes.** Hamilton Young Castner, 55, Chancery lane, London.

OCTOBER 21.

19850. **Improvements in tools applicable for use in putting up electric light fixtures and for other purposes.** Charles Bishop, 6, Lord street, Liverpool.

19851. **Improvements in or appertaining to the hearing and of receiving telephones speaking tubes and the like.** William Phillips Thompson, 6, Lord street, Liverpool. (Partly communicated by George Vaugham Benjamin, United States.)

19857. **An appliance for arresting induced electric currents of high potential.** Walter Claude Johnson and Louis John Steele, 28, Southampton buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1884.

16805. **Electric lamp carbons.** Wynne and Powell. (Second edition.)

1889.

10082. **Electric switches, etc.** Binswanger. (Second edition.)

1890.

19740. **Telegraph receivers.** Higgins. (Second edition.)

1892.

7226. **Electric treatment of metal, etc.** Hoho and Lagrange. (Second edition.)

19248. **Electrical conductors.** Webber and others.

21696. **Electric smelting of aluminous ores, etc.** Willson.

21803. **Electric transformers.** Brown.

22061. **Electric motive power system.** Spence and others.

1893.

1391. **Electric arc lamps.** Schleyder.

1948. **Secondary voltaic batteries.** Imray. (Société Anonyme pour le travail électrique des Métaux.)

13081. **Secondary batteries.** Pitkin.

14315. **Galvanic elements.** Hertel.

15257. **Galvanic batteries.** Marcus.

16027. **Electrical mains.** Siemens Bros. and Co., Limited, and Knorr.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2½
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13
Electric Construction	—	1¾
House-to-House	5	2½
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	7
National Telephone	5	4¾
St. James', Pref.	—	8½
Swan United	3¾	3¼
Westminster Electric	—	5¼

NOTES.

Saint-Geoire.—This town, in Isère, comprising 2,000 inhabitants, is to be electrically illuminated.

Fire Alarms.—A correspondent suggests the adoption by the London County Council of improved fire alarms.

"Mechanics."—The first number of a new monthly journal bearing this title will appear with the new year.

Battersea Polytechnic.—Dr. W. E. Sumpner has been appointed head of the electrical department of the Battersea Polytechnic.

Fire.—The "fusion of electric wires" is attributed by the fire brigade as the cause of a fire this week at the Raleigh Club, in Regent-street.

Lighting Mail Cars.—The German postal authorities, as a result of experiments, have resolved to electrically illuminate the postal cars on the railways.

Transmission of Power.—A lecture on this subject has been delivered before the Leeds Association of Engineers by Prof. Goodman, of the Yorkshire College.

Damaging Telephone Wires.—Three months' imprisonment was the sentence meted out to a Glasgow man for cutting down and stealing 4,080ft. of telephone wire.

Croydon.—The County Council have instructed the town clerk to apply for a provisional order authorising the construction of a tramway between North End and South End.

Envermeu.—This small town, containing 1,500 inhabitants, and situated in the Seine Inférieure, is lighted by electricity. Water power is used to produce the electrical energy.

Crystal Palace.—The Gulcher dynamos and lamps which have for some years been used in the lighting of the Palace, have been superseded by Crompton machines and arc lamps.

Bremen.—The municipal electricity works commenced the supply of light on September 30. There are 20,000 lamps now connected to the mains and distributed over 350 installations.

City Telephone Tubes.—A reply has been received by the Commissioners of Sewers from the City of London Electric Lighting Company in regard to the telephone tubes laid down by the latter.

The Junior Engineering Society.—On Friday, the 10th inst., at the Westminster Palace Hotel, at 8 p.m., Mr. John Wolfe Barry, M.Inst.C.E., will deliver his presidential address before this society.

Hydraulic Power.—The supply of hydraulic power to the public by the Corporation will begin on February 1. This will enable water-motors to be used for driving dynamos for electric lighting purposes.

Post Office Secretary.—The Postmaster-General has appointed Mr. Spencer Walpole, Lieutenant-Governor of the Isle of Man, to be secretary of the Post Office in the place of the late Sir Arthur Blackwood.

The Inspection Dodge.—Three months' imprisonment was the award made the other day to a "respectably-dressed young man" for pretending to be an inspector of electric light installations in Westminster.

Telephony in India.—There are now 23 telephone exchanges in India. The type of telephone to be used by the Indian Telegraph Department for public use is the same as that employed in the British Post Office.

The Phonopore.—On Monday, in the telegraphic classroom of the Birmingham Technical School, Mr. Whitehouse, the instructor in telegraphy, gave a lecture on the phonopore invented by Mr. Langdon Davies.

Coal-Cutting Machines.—The attention of coal-owners is, it is said, again being directed to the use of electric coal-cutting machines, and trials on a large scale are reported as being made in some of the coalfields.

Traction in Japan.—There are no less than 11 new railways under consideration in Japan, two of which are electric—one from Kobe to Mitamachi, 17 miles long, and another from Sogo to Ozuma, a little over 11 miles long.

Gas in London.—The inhabitants in various parts of the North of London are complaining of the high charge for gas. Delegates from vestries and local boards are considering the matter. Why not undertake electrical illumination?

The Institution of Electrical Engineers.—The first meeting of the 1893-4 session will take place on Thursday, the 9th inst., when a paper will be read by Prof. George Forbes, F.R.S., on "The Electrical Transmission of Power from Niagara Falls."

Berlin.—A dividend of 8½ per cent. for the past year has been declared by the Berliner Elektricitäts Werke, the company which supplies current to some 160,000 incandescent lamps in Berlin, and also electrical energy for the operation of motors.

The Telephonic Athletic Association.—The inaugural smoking concert of the season will take place this (Friday) evening at The Haunch of Venison, Bell-yard, Temple, E.C. The proceedings will commence at 7.30 prompt, Mr. Dane Sinclair presiding.

Potash.—The United Chemical Works at Leopoldshall are about to commence the production of potash according to an electrolytic method. Similarly, the Allgemeine Elektricitäts Gesellschaft are erecting plant at Bitterfeld, and will compete with the former in the manufacture of potash.

Fire Risks.—The first of a course of six weekly lectures upon "Fire Risks of Electric Lighting" was given at the Manchester Municipal School of Electrical Engineering, by Mr. Haldane Gee, to a large gathering of members of the Insurance Association of Manchester, on Tuesday evening.

Lectures.—Mr. J. Swinburne is announced to give, on the 21st inst., at the Royal Victoria Hall, Waterloo-road, a lecture on "The Mechanics of Street Toys." During the coming session of the Greenock Philosophical Society, Prof. James Blyth will deliver an address on "Recent Ideas on Electricity."

Warning.—The police warn householders and keepers of offices in the City and the metropolis generally of the danger incurred by the admittance of unauthorised persons to roofs and other parts of buildings, on the assumption that they have been ordered to inspect telephone and telegraph wires.

Tell-Tale Indicators.—The Admiralty have directed the dockyard officials at Devonport to so arrange the engine indicators of the "Bonaventure" that they may be readily seen by the officer conducting the ship from either the fore bridge, poop, or conning tower in the same way as the ordinary telegraphs.

Lighting at Kingston.—The principal streets of Kingston-on-Thames were illuminated on Wednesday evening with the electric light for the first time. There are 36 arc lamps in the streets, of 1,000 c.p., and which displace 75 gas lamps. The formal opening is announced to take place to morrow.

Type-Setting by Telegraph.—A system for accomplishing this object is said to have been devised by Mr. Donald Murray, of Sydney. Mr. Murray claims that it is possible by his invention to operate at a distance, over a single telegraph wire, a typewriter, a type-setting machine, a piano, or any other keyboard instrument.

Society of Engineers.—The next ordinary meeting of this society will be held at the Town Hall, Westminster, on Monday, when a paper will be read on "Collieries and Colliery Engineering," by Mr. R. Nelson Boyd, M.Inst.C.E. The annual dinner will take place at the Holborn Restaurant on Wednesday, the 14th December.

The Paris Exhibition.—It is intended at the proposed Paris Exhibition of 1900 to give object-lessons in the manufacturing arts, beginning with the raw materials. The transmission of power by electricity will admit of machines being placed everywhere, and render it easy to show how wheat in the husk is thrashed, winnowed, and ground.

Telephony.—Communication by telephone is about to be established between Scarborough and York, with an exchange at Malton. York and Leeds are already connected by telephone, so that business men spending their holidays at Scarborough will be enabled to communicate direct with the capital of the West Riding and other places.

Electric Tramway for Aberdeen.—As mentioned in our last issue, an electric tramway is suggested to be constructed in this town. It would start from Castle-street and proceed thence by the proposed new carriageway to the sea-beach promenade, and return across Links to Wellington-street, along quay, and up Marischal-street to the starting point.

Lighting at Budapest.—The supply of electric light was commenced on the 14th ult. by the Hungarian Electricity Company, who have adopted the alternating-current system designed by Messrs. Ganz and Co. The plant comprises six boilers and three engines of 600 h.p., and one of 300 h.p., together with corresponding alternators, capable of energising 30,000 16-c.p. lamps.

Agriculture.—It has been suggested, remarks a daily paper, that tramways from town to town and village to village, with sidings at farms, might remedy the present difficulty of high rates charged for carriage by rail. It is submitted that either horses or electromotor cars might be used for the purpose, and by this means a far better supply of all kinds of produce might be poured into the towns.

Institution of Engineers and Shipbuilders.—The first general meeting of the session will be held in the Physical Lecture-hall of the Durham College of Science, Barras Bridge, Newcastle-upon-Tyne, on Tuesday next, at 8 p.m. The president will address the members, and a paper will be read "On a Method of Comparing Steamship Performances, and of Estimating Powers and Speeds of Ships," by Mr. W. Hök.

Electric Parcel Cars.—A Manchester paper states that electrical parcel cars, somewhat resembling in shape the parcel-post vans, will soon be seen in the streets of London. It is estimated that for every mile run by an omnibus of one of the great companies the cost for horse traction is exactly 5d., while the cost of running an electric car would, it is submitted, be as low as 2½d. The accumulators have been made so that they can be charged to last for four hours' work.

Leeds Tramways.—The Highways Committee of the Corporation have made arrangements with the Thomson-Houston Company for the temporary letting to them of the Roundhay tramway line on the same terms as those upon which it was formerly let to Mr. Graff-Baker. The lease is for six months certain, determinable thereafter by a month's notice on either side, this arrangement being made so that the line may be subsequently let along with the general tramway system of the city.

Electric Fittings.—A copy of their catalogue of electrical fittings has been forwarded to us by Messrs. Wm. McGeoch and Co., of 10, Berners-street, W. Among the large variety of fittings and accessories dealt with may be mentioned double-pole switches, sudden-break adjustable contact switches, regulating switches, china cut-outs, ceiling roses, "Unique" and tumbler switches, sockets, globe-holders, hall fittings in polished brass, standards, brackets, etc. The company are contractors to the Admiralty for ship fittings.

Motive Power on Ships.—The battleship "Jauréguiberry" will rank among the most powerful vessels of the French navy. A remarkable feature of the "Jauréguiberry" will be the extensive use of electricity as a motive power. It will move the turrets, raise the ammunition, and do much other work which in the majority of modern ironclads is done by steam or by pneumatic or hydraulic power; it will also, of course, light the vessel. The ship will contain 550 incandescent lights, and there will be six very powerful Mangin search-lights.

Oil as Fuel.—Experiments are being made at the Thorncliffe Ironworks, in Sheffield, with oil as a substitute for coal for heating boilers, etc. The large boilers, which supply steam to nearly all the machinery near the blast furnaces, are being used for experiments. The oil is placed in a cistern over the firing place, and by means of steam-jets forced under the boilers, where it is ignited, the result being flames of intense heating power sufficient to produce steam of a pressure of 80lb. to 100lb. The results of the experiments are said to be highly satisfactory.

Chicago Exhibition.—This exhibition has now been closed. Messrs. Hoveler and Dieckhaus have been awarded the first prize (medal and diploma) for their tandem bearing metals, the firm being the only one of those having exhibited in the same section who received an award for anti-friction metals. The first prize gold medal has been awarded to the "Victor" turbine made by Mr. F. Noll. We are informed that the medal for the best flue feed-water heaters has been awarded to the Fuel Economiser Company, of Matteawan, N. Y., for the Green fuel economiser.

Exhibition of Industry.—An exhibition of industry will be opened in Lochee-road, Dundee, in December. It is promoted by the Dundee and District United Trades' Council, and is to be on lines similar to the previous one of 1887-88. In addition to exhibits from manufacturing firms, the exhibition will afford an opportunity for the production of inventions, etc. The exhibition will consist of three sections: (1) industrial or domestic work; (2) trades and manufactures; (3) art. In the second section, Class 21 will comprise electrical engineering and appliances, and Class 22, gas engineering and appliances.

Cambridge.—The new science building which has been erected by the governors of the Leys School, Cambridge, was opened on Saturday by Lord Kelvin. The building, which has cost a little over £4,000, contains four laboratories on the ground floor, chambers in the basement for electrical work, three lecture-rooms upstairs, the largest of which has been named the Kelvin Room, and various other rooms for scientific work. The object of the governors in establishing a science department has been to enable the boys to go into the university thoroughly prepared to enter upon a scientific course of education, and well grounded in practical work.

Telephoning Telegrams.—A joint arrangement between the postal authorities and the National Telephone Company will come into operation in Leeds on Monday. The head telegraph office will be connected with the telephone company's exchange in Park-row, and its subscribers, on making a deposit with the company to pay the cost of telegrams, will be able to telephone telegrams for transmission to all parts, instead of handing them in at branch telegraph offices. Inward telegrams for subscribers within the Leeds postal area may for convenience be telephoned on arrival through the National Telephone Company's exchange instead of being delivered by messenger.

The Choice of Meters.—This subject is dealt with by M. G. Claude in *L'Industrie Electrique* of October 25th. The writer concludes that in important installations, where one desires to ascertain the energy consumed with great exactness, and where the meter rent is relatively insignificant, it is advisable to use the energy meter. On the other hand, in the case of small installations the employment of the intensity meter can only be advantageous, and the generalisation of the method adopted at the Vincennes station (which, however, M. Claude does not describe) in this respect could only result favourably from the point of view of the development of small installations.

Can We Do Without Coal ?—This is practically the text of the subject dealt with in an article by M. A. Moutier in *L'Electricien* of October 28, and entitled "The Miners' Strike." The author asks whether coal is the only article from which we can obtain the power we require, and he replies in the negative. As alternatives, he suggests the utilisation of the wind and of water power. There are, he says, two methods of employing electricity produced by these agencies. One is by the transmission of power by electricity by the use of overhead or underground conductors, and the other by the aid of accumulators. He submits that the latter method is to be preferred.

Telegraphic Dictionary.—The International Telegraphic Bureau of Berne is compiling an official vocabulary for telegrams in a language agreed upon for the purpose. The book, on which, amongst others, English, Dutch, and Spanish functionaries have laboured, will comprise at least 240,000 words, selected from the English, German, French, Italian, Spanish, Latin, Portuguese, and Dutch languages. It is said that the composition will be complete by next March, when it will be immediately issued for sale. Not for three years, however, will it be in general use. The International Telegraphic Congress, which will take place at Budapest in 1896, may possibly recommend the Postal Union to adopt it.

Registering Lightning Strokes. — An apparatus intended to register the number of times a lightning conductor has been struck by lightning has been devised by Messrs. Siemens and Halske. A cast-iron box contains the mechanism, which comprises a bar of iron which is magnetised by the current passing along the conductor and caused to deviate against a spring, this displacing a needle on a dial. A screw stop prevents the movable piece from passing beyond a certain limit. The whole of the mechanism is fixed on the cover of the box in such a manner as to be readily accessible, and the sensitiveness is such that a momentary intensity of current of at least 250 amperes is necessary to cause the index to move.

Personal.—Prof. von Helmholtz, who recently returned from a visit to the Chicago Exhibition as the official representative of Germany, was born at Potsdam in 1821. His early discoveries were mostly confined to microscopy and fermentation, though his wide learning soon made itself felt in all branches of science. His great invention was perhaps the ophthalmoscope, the discovery of which, in 1851, caused sensation in the scientific world, and has been the means of saving the eyesight of thousands. In 1871 he took the chair of physics at the University of Berlin, where most of his electrical researches were carried out; and in 1887 he accepted as well the control of the new physico-technical institution in Berlin, which was founded chiefly by the late Dr. Werner von Siemens.

"Machine Drawing."—We have received a copy of "Machine Drawing," a book intended for the use of students in science and technical schools and colleges. The work, the authors of which are Messrs. T. Jones, M.I.M.E., and T. Gilbert Jones, Wh.Sc., comprises 40 plates of machine details, with descriptive letterpress and numerous perspective illustrations. Exercises are given requiring the student to test his power of making original drawings by deducing from the complete views given others which are not contained in the book. For this purpose the descriptive letterpress and notes and exercises provided with each drawing, and the perspective illustrations, will prove of great assistance. The book, which is published by the authors at 27, Barton-street, Moss Side, Manchester, should be of value to the large section of students to whom it appeals.

Lightning Conductors.—A danger incurred in fixing lightning conductors, in the ordinary fashion, to high chimneys is pointed out by a correspondent. Owing to impurities in the coal, gases are given off in the smoke from the fires below, and which are said to oxidise the lightning bar, and so eat completely through the rod, or materially reduce its section. In order to avoid accidents from the above cause, a method has been adopted at some works in Germany of surrounding the metal bar in a system of glass tubes, the space between the glass and metal being filled up by a special kind of cement. The upper end of the highest tube is sealed hermetically, allowing only the platinum point of the bar to project. The glass not being susceptible to chemical action, either from smoke or atmospheric conditions, protects the lightning rod from being eaten through or diminished in section by oxidation.

Electrical Train Staff Working.—From a recent return embodied in the Blue book on "Railway Signal Arrangements and Systems of Working," we learn that out of a total distance of 4,345 miles of single line in England and Wales, 1,020 miles, or nearly one quarter, are operated upon some approved electrical train staff or tablet system, such, for instance, as that devised by Mr. F. W. Webb, chief mechanical engineer of the London and North-Western Railway, in conjunction with Mr. Thompson, the company's signal engineer. The Cambrian leads the van in this direction with 174 miles, the Great Western has 143, the Midland 106, the North-Western 103, and the South-Western 88. In Scotland, out of 1,658 miles of single line, 480 are worked in this way: the Caledonian having as much as 259 miles alone, and the North British 105. The proportion in Ireland is still greater, out of 2,240 miles open for traffic, 995, or nearly half, being worked with electrical train staffs.

The Government and the Telephones.—The London correspondent of a Manchester paper learns that the Postmaster-General may not improbably consent to the appointment of a parliamentary committee to consider and report upon the proposed arrangements between the Post Office and the National Telephone Company, and generally on the future policy of the Government in regard to the extension of the telephone service. The reasons for this change of attitude on the part of the Post Office are said to be the facts that the movement for the municipalisation of the telephones has been gaining in strength, and that the

case for the corporations was not heard before the Select Committee on whose report the policy of the late Government was framed. But there is also understood to be a desire on the part of the postal authorities to consider the question of State acquisition, to which the period that has now been reached in the license of the National Telephone Company had given a present interest and importance.

An Important Electric Railway Trial.—The managers of the Intramural Electric Railway at the Chicago Exhibition having felt that trains much heavier and longer than are ordinarily run could be operated, recently made a trial to prove that this was the fact. Mr. W. E. Baker, manager of the Intramural line, late at night started out a train composed of one live motor car, two still motor cars, and nine empty cars, weighing in all about 196 tons. This heavy train was pulled along, apparently, without effort, even when it turned the loops at either end of the line, each of which has a radius of over 100ft. On the following day, which was Railroad Day, invitations were issued to the railway magnates assembled at the exhibition, and a train of eight cars (one motor car and seven trailers) was provided. The train was loaded to its fullest capacity, no less than 800 persons being carried. The motors ran smoothly at their maximum speed, and the test was satisfactory in every respect. The weight of the train can be conservatively estimated at 212½ tons.

Cardiff Tramways.—In the course of a communication to a Cardiff paper with regard to the municipalisation of the tramways, Mr. W. N. Colam cautions the members of the Corporation against committing themselves to opinions of the best motive power for Cardiff from information they may have gleaned from America. He states that the adoption of a motor for American streets is no guide, but, rather, misleading, as to what could be tolerated in Europe. It is also to be remembered, he remarks, that the spheres of useful work for electricity and cable are quite distinct and separate, and this is evidenced by the fact that the cable system has just been installed and set to work in the two most important streets of the United States—viz., Broadway and Third-avenue, New York—whilst systems of electric haulage are very frequently applied under different conditions of traffic. Mr. Colam suggests that members of the Corporation, individually or collectively, should make enquiries as to the conclusions arrived at on this all-important question by the cities of Edinburgh, Newcastle, Glasgow, Birmingham, and London

A New Method of Suspending Motors.—Among the improvements which the introduction by the General Electric Company of the new "G. E. 800" street-car motor has brought into street-railway practice, is a new method of suspending the motor on the axle and the truck, whereby it is made to rest upon a resilient system, the weight being supported at a point immediately below the centre of gravity of the motor itself. This system of suspension is known as the cradle suspension. Immediately below the armature bearings are trunnions on each side of the motor, set in side bars, which are pivoted at the front to a special casting, and supported at the rear end from link bars bolted to the truck frame. The front special casting is mounted upon six springs, two of which offer resistance to pressure upwards, and form resistance to the downward pressure. It will thus be seen that this modification is of significance in electric railway practice. The motor being set upon a spring-like cushion, the greater part of the dead-weight is taken off the axle itself and is more evenly distributed to the axle bearings and that part of the truck which can better stand the strain. This, in conjunction with the extraordinary lightness of the motor, means economy of track maintenance and a decrease in the possibility of accident to the axles. A series of careful tests have already shown the value of the improvement, which promises to become general where the "G. E. 800" is used.

Electrical Purification of Sewage.—Some interesting sanitary experiments are being carried out at Havre on the Hermite system in connection with the Exhibition of Hygiene. This system is based upon the electrolysis of sea water. The electric current decomposes the chloride of magnesium, whilst the chloride of sodium serves as a conductor. The result is a liquid disinfectant of great power. It is almost odourless, leaves no residuum when used for purposes of flushing, and is perfectly inoffensive. Although sea-water renders the application of this system considerably cheaper, it is not essential to it. When not procurable, a solution of chloride of magnesium can be used instead. At Havre, M. Hermite has found the opportunity for which he has long been waiting. There is sea-water in abundance, and an enterprising municipality. A central station has been constructed, supplied with the necessary electrical plant and convenient tanks, in which the disinfectant is prepared in sufficient quantities. By a simple arrangement of pipes and ducts this is distributed through the streets like water or gas. It can also be laid on to the houses, which, when once supplied with the disinfectant, help to purify the main drain, instead of adding, as is now the case, to the general contamination. Sewage thus treated has been submitted to severe examination, but French bacteriologists are said to have sought in vain for those microscopic forms of life which wage a constant war with the human race. If all that the French sanitary engineers claim for M. Hermite's system be true, great improvement will take place in the health of any town adopting it. It has been applied to the Quartier Saint-François, and those who have seen its effect have been deeply impressed.

Electricity Applied to Irrigation.—An interesting series of experiments in the way of irrigation by sewage is being conducted by Mr. W. S. Freeman, of Otford. The trials are being made on a portion of Boughton Farm, Otford, which has been placed at the disposal of the operator by Mr. Greenlees, and the work has been confined to a hop garden of about eight acres and an adjoining meadow through which the main sewer runs. This is some distance from Mr. Freeman's works, where the electricity is generated by a large waterwheel geared to a Crompton machine capable of working up to 1,250 volts and 15 amperes. From here the current is led by overhead wires to the scene of operations, where a 6½-h.p. motor works a 3in. centrifugal pump having its suction pipe placed into the sewage. Attached to the pump is a series of iron pipes, conveyed on stands at the height of about 20ft. to the upper end of the hop garden. Through this pipe the liquid is conveyed, and delivered into a trench, from which there are tributary trenches running down each alley and diverted on to each hill. The delivery of sewage by this means varies from 3,000 to 5,000 gallons per hour, and it is estimated that each hill receives about 20 gallons of liquid. In this way an area of two acres were covered per day, with the assistance of two labourers only, and at the nominal cost of £1 per acre, or 1¼d. per ton of sewage. Previous to commencing the work the hops to be treated had suffered severely from the drought, the leaves having died off, and the bine being very attenuated. At the present time the plants have a healthy appearance, the bine has been resuscitated, and in place of the decayed "pin" fresh laterals have commenced to shoot strongly, while the leaves are fresh and sturdy. During the last day or two of the experiments the sewage was diverted into channels formed through the meadow above mentioned, and the

benefits likely to accrue are already manifest in the increased succulence and strength of the pasturage.

Magnets and Electric Currents.—The third of the Gilchrist lectures at the Assembly Hall, Mile End-road, was delivered last week by Prof. J. A. Fleming on "Magnets and Electric Currents." The oxy hydrogen lantern was brought into play in throwing picture shadows of the magnets and other apparatus in operation upon the screen. The lecturer started by explaining the natural magnetism of the "loadstone," which is chemically known as magnetic oxide of iron, and showed that it was capable of transferring its magnetic properties to pieces of steel, although not to soft iron. The peculiar properties of a balanced magnetic needle in placing itself north and south were next illustrated, and likewise the system upon which telegraphic messages are sent by the old needle instruments. Any magnetised piece of steel suspended on a pivot and surrounded by a coil of wire would place itself at right angles with the coil so soon and so long as a current of electricity was allowed to pass through the coil. The lecturer demonstrated by experiments the fact that a magnet has a soul as well as a body, and showed by means of iron filings the lines of magnetic force flowing around a magnetised bar. The galvanometer was then introduced as preliminary to an explanation of the meaning of galvanic currents. He had a very sensitive Thomson reflecting galvanometer on the operating-table, arranged to throw a spot of light from the lantern on the screen. This invention, it was explained, was essentially a minute mirror fastened to a delicately-suspended magnetic needle swinging inside a coil of wire, through which electric currents were passed. The principle on which cable messages are sent across the Atlantic was described, it being incidentally stated that the aurora borealis had a curious effect when present in the northern skies of disturbing the swing of the magnetic needle. It was, he said, believed that the aurora were electrical phenomena, and they indicated electrical disturbances in the earth, which was itself a big magnet. Next came the formation of artificial magnets, or electromagnets, by sending powerful electric currents through wire coiled round bars of soft iron. As long as the current continued to flow the iron was strongly magnetic, but this property ceased as soon as the current was stopped. Having thus obtained magnetism from electricity, the lecturer next reversed the process, and obtained electricity from the act of moving a magnet in and out of a coil of wire. This led to the dynamo-electric machines of the present day, a sketch of which was given, and a brief description of the electric light and other modern applications of electricity. In conclusion, portraits of electrical celebrities—the brothers Siemens, Edison, Swan, Kelvin, Clerk-Maxwell, and Faraday—were thrown on the screen.

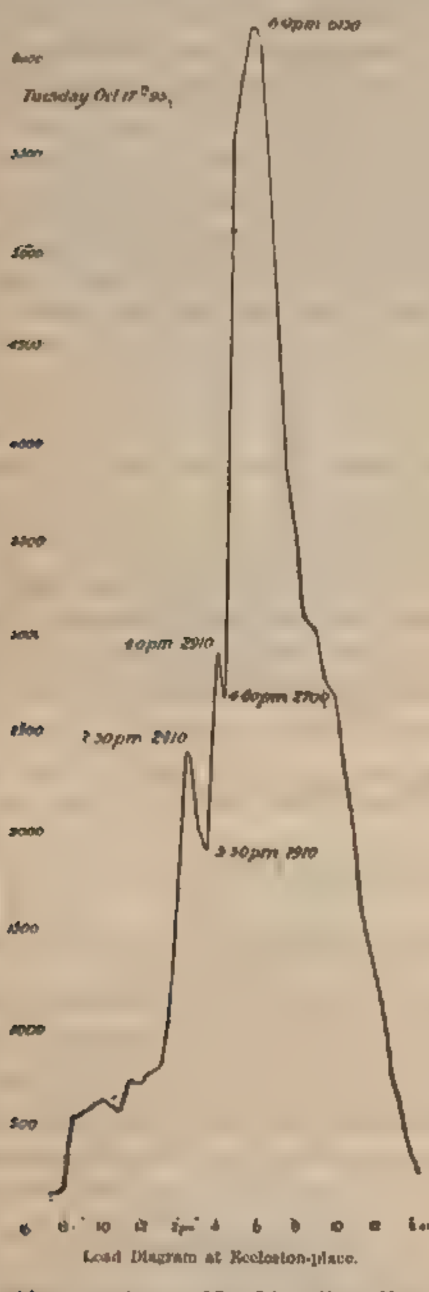
Combined Rotary and Direct Current Station.—The electricity works in Bockenheim, a kind of suburb of Frankfort-on-the-Maine, possess various features of more than ordinary interest. The station was designed to deal with both lighting and motive power, Bockenheim containing many large and small industrial works requiring motive power. A lengthy illustrated description of the station, which was built and equipped by Messrs. Lahmeyer and Co., is given by Mr. F. Uppenborn in the *Elektrotechnische Zeitschrift* of October 27. The station supplies the town with two currents—one is a high tension rotary current, and the other a low-tension continuous current. The E.M.F. of the former, which is used for the operation of motors, is 660 volts; that of the latter has a pressure of 110 volts, and is employed for lighting and for the energising of electromotors of small power, as, for instance, up to 3 h.p. The plant comprises two water-tube boilers by Simonis and Lanz, of Frankfort-on-the-Maine, and constructed for a working pressure of up to 150lb., and provision is made for the laying down of two additional boilers. There are two engines of the horizontal tandem compound condensing type, by Messrs. Pokorny and Wittekind, of Bockenheim, giving 250 h p. when running at 96-100 revolutions, and capable of also working non-condensing. Each engine is coupled direct to a low-tension rotary-current machine, these dynamos having the same arrangement as those of the Brown type used in the Lauffen-Frankfort plant. These machines at 100 revolutions and 80 alternations give 80 volts terminal pressure, and their output amounts to 130 kilowatts, or about 200 h.p. From the flywheels of the engines are driven by belts two Lahmeyer direct-current dynamos yielding 110 to 150 volts at the terminals, and an out-turn each of about 33 kilowatts. These machines serve partly to excite the rotary current dynamos and partly to charge accumulators, and to supply continuous current to the surrounding district. In order to allow both of the continuous-current dynamos to feed into the continuous-current network, and yet to have available the extra pressure necessary in the charging of the accumulators, an auxiliary dynamo has been brought into requisition, this being direct coupled to a rotary-current motor. The continuous-current network is arranged on the two-wire system. Connected on one side of the continuous-current omnibus bars are the two dynamos and the battery of accumulators, and on the other side the feeding mains of the continuous-current network. The battery, by means of a double-cell switch, stands in connection on the one hand with the omnibus bars, and on the other with the dynamos. The battery comprises 64 Tudor cells, having a capacity of 430 ampere-hours. With regard to the rotary-current dynamos, the current is conveyed to the switchboard, and it then passes through three safety fuses and an ammeter, and by means of three switches it reaches the low-tension rotary-current omnibus bars. These dynamos are put in circuit through a voltmeter, voltmeter switch, and a "phase" indicator. The latter consists of three pairs of incandescent lamps in series, which on the one side are connected to the three omnibus bars, and which on the other can be put in connection by a triple switch with the rotary-current machine to be placed in circuit. On the insertion of a rotary-current machine, its tension is at first brought to the same pressure as that of the omnibus bars. Upon this the phase lamps are put into communication with the machine. When this is done, the disturbances due to the alternating lighting up of the three lamps show themselves. The speed of the machine to be put into circuit is then regulated until the disturbances cease and the equal phase is present. This is ascertained by the complete extinguishment of the lamps. If this is attained, the machine can be inserted, and the synchronism of both machines is maintained steadily with a certain power. Three conductors are led from the low-tension omnibus bars to two converters, which transform the current from 80 volts to about 700 volts. From the secondary windings the three conductors pass to a switch, safety fuse, and to the high-tension omnibus bars, which are connected by safety fuses to the feeding mains. In the interior of the town the cables for both direct and rotary current are laid underground. They are of the Felten and Guilleaume iron-armoured lead cable type, those for the rotary current being triple-concentric, and for the continuous current simple cables are used. Outside the town overhead wires are used. The rotary-current unsynchronous motors energised from the network—and of the whole 400 h.p. in the local factories no less than 200 h.p. are supplied from it—are operated *direct* from the high-tension mains.

ELECTRIC SUPPLY COMPANIES.—I.

(Continued from page 374.)

WESTMINSTER ELECTRIC SUPPLY—DAVIES STREET STATION.

The third and largest central electric station of the Westminster Electric Supply Corporation is situated at the top of Davies-street, Berkeley square, W. The station occupies the greater part of a really fine pile of red brick buildings, in the modern Victorian style, dominated by a tall and well-proportioned chimney, from which floats continuously a light cloud of steam, for the engines here exhaust into the air. Sets of chambers and shops occupy the rest of this building, and the station is reached through two gateways with wrought-iron gates, while the engineer's house forms part of the same block.



Load Diagram at Eccleston-place.

The resident engineer, Mr. Llewellyn Foster, is the earliest of those who joined the engineering staff of the Westminster Corporation. The first start of electric supply in Westminster, it will be remembered, was made at Dacre-street, where plant for lighting the block of buildings including Victoria-mansions and the Members-mansions was erected in 1889. The plant there used was supplied by Messrs. Crompton, and Mr. Foster took command, having then just returned from electric pioneering in Australia to devote himself to central-station work in London.

There is not another more interesting station in its line that could occupy the attention of the electrical engineer. Davies-street station is, we can easily imagine, the pride of Prof. Kennedy's heart, and the engineer-in-charge seems to feel the same sentiments. The daily maximum output is now over 6,000 amperes, and the total number of lamps supplied from this station is now (in October, 1893) 63,500 8-c.p. lamps. And still the demand keeps increasing in a degree beyond that even anticipated in this influential district, so that the addition of a new 350-h.p. set of engine and dynamo, which has just been put down, comes none too soon.

The district of supply comprises the fashionable West-end quarter known as Mayfair, and extends along Oxford-street, from the Circus to the Marble Arch, and from Park-lane along Piccadilly as far as Bond-street, then up Old Bond-street and Conduit-street into Regent-street. In Oxford-street it is the south side only that is supplied by the Westminster Corporation, the north side falling within the district of the Metropolitan Company.

The staff at Davies-street is composed as follows: resident engineer, Llewellyn T. Foster; second engineer, H. Howard Baker; third engineer, G. Horley. The working staff comprises 18 men—viz., an engine staff of two switchboard attendants, one battery attendant, two head drivers, two assistant drivers, and two cleaners; and boiler staff including three head stokers, two assistant and two coal-trimmers; the remainder comprise carpenter, store-keeper and clerk.

STATION.—Davies-street station was opened on March 25, 1891, with four engines and dynamos—two 80 h.p. and two 140 h.p., the two 80-h.p. Willans engines with Crompton dynamos being those removed from the Dacre-street station. The building was designed by Mr. Peach, the same architect as for the other Westminster stations, and was built by Messrs. Holliday and Greenwood, of Loughborough-road, Brixton. The supply of current was commenced with 1,500 lamps connected, the engine power being 440 h.p. During the building operations, the plant was run under a wooden shed with a temporary chimney, and, in fact, the premises have only been completely finished last year. There are now 11 engines—six 200 h.p. and one 350 h.p. sets having since been added, making a total of 2,000 h.p.

The engine room is an exceedingly fine one—size, 90ft. long by 47ft. wide, very high and open, and covered with a glass roof. The height gives corresponding coolness and freshness, and the glass roof is of great advantage in gauging the probable weather. When darkness falls the load frequently goes up from 800 amperes to 4,000 amperes in 20 minutes, and in times of snowstorm or shifting fog the load will frequently rise 2,000 amperes or more in five or six minutes; and as the gathering gloom can be seen through the roof by the engine-men, no time is lost in starting engines.

In entering the station one walks straight into the engine-room from the carriageway, down a flight of steps to the engines or up a few steps to the switchboard. A staging is erected at the near end for carts to unload, a 10-ton travelling crane carrying the load to any desired spot. The present line of engines and dynamos occupies the whole of the left side of the engine-room, and the new 400-h.p. engine is placed at the further end to the right. Foundations for a second 400-h.p. engine are already laid, and there is room in all for eight or even nine more such sets to complete this second line of engines.

BOILERS.—The boiler-room is 2ft. lower than the engine-room. Its size is 72ft. by 43ft., and the accumulator-room is above, of the same size, on concrete floor carried on girders.

There are seven boilers—five Davey-Paxman modified marine type boilers (steel boilers 12ft. long by 8ft. diameter), as at Eccleston-place, and two Fraser boilers of similar type. The grate surface of each is about 30 square feet, and they evaporate 5,000lb. of water per hour. The feed-water is pumped through two feed-water heaters before reaching the boilers. The working pressure is 160lb., for which the boilers are designed.

The same arrangements of weighing coal (on weighbridge and balance) and of measuring feed-water by meter are here employed as at Eccleston-place, and the same kind of coal—best Welsh smokeless—is used. The piping also is similar, steel pipes with copper bends, 8in. diameter, all slung from

brackets above to allow of easy expansion. A complete double steam service to each engine is given.

The chimney shaft is 160ft. high, 11ft. square at base, and 8ft. square at the top.

ENGINES AND DYNAMOS.—Willans engines are installed throughout, compound and non-condensing.

Two 80-h.p. engines run the balancing machines.

Two 140-h.p. engines come next, for the first set of 225-volt dynamos. These engines were specially made for this station, and run at 170 revolutions with extra long stroke.

Next, there are six 200-h.p. engines driving Crompton and Elwell-Parker dynamos, and, lastly, one 350-h.p. Willans three-line compound, strengthened.

The dynamos comprise two Crompton two-pole dynamos of 45-kilowatt capacity—the balancing machines—giving 120 volts and 375 amperes. The next group are two Elwell-Parker (E.C.C.) four-pole machines, giving 65 kilowatts—220 volts and 300 amperes (working usually up to 350 amperes). Of the six sets of 200 h.p., two are Crompton four-pole machines, 112 kilowatts (225 V. and 500 A.), and four are E.C.C. two-pole dynamos of the same capacity—very good working machines—which in practice give without trouble almost any output that the engine can generate.

The 350-h.p. engine drives a Latimer Clark Muirhead dynamo of 225 kilowatts (1,000 amperes at 225 volts). This set has been tested at the makers' at full power, and gave 84 per cent. combined efficiency. This dynamo is remarkable as having the highest efficiency of any machine of similar large output by these makers: the shunt current is 9·5 amperes at a full output of 1,000 amperes.

Copper-gauze dynamo brushes are used throughout, and sight-feed lubricators are fitted to all bearings, the oil being used again and again after being filtered.

It will be seen that there is an excellent selection of subdivided units at this station—any power from 180 h.p. up to 2,000 h.p. can be run at almost full load. Very particular attention is paid to this point—the great aim of the engineer-in-charge is always to run the engines at full load as long a time as possible. Continued care in this direction often makes the difference between running the plant at 50 per cent. and at 65 to 70 per cent. efficiency—a difference that soon shows with an output of some thousands of amperes. An illustration will show how careful are the engineers at the station. At about 11 o'clock at night the load is generally 1,600 to 1,700 amperes, and at 11.30 it has dropped to 1,400 amperes; this latter load can just be taken by the two slow-speed engines, therefore the 200-h.p. engines are shut down directly the load falls to this point, and the two smaller engines take up the load and work for a certain time at full efficiency. The same consideration of high efficiency by running at full load governs all the combinations as far as it is possible to accomplish. It is not contemplated to use larger units than 350 h.p. on the Westminster system.

SWITCHBOARD.—There are seven feeders going from the switchboard to Oxford-street, Mount-street, Curzon-street, Arlington street, Grafton-street, Bond street, and Hanover-square. The switchboard is of the same type as those in use at the other stations. Automatic magnetic cut-outs are provided for every dynamo. The board is fitted with its full complement of voltmeters, but in practice the pressure is read on a pair of voltmeters placed on the gallery rails in front, carefully calibrated every week. The pressure at the feeding points is so regulated that consumers get 100 volts at their lamps.

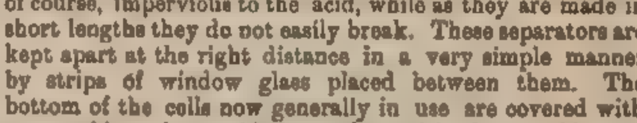
ACCUMULATORS.—The battery of accumulators is of the same kind as at the other Westminster stations—two sets of 56 Crompton-Howell 500 ampere-hour cells, of which 12 are regulating cells. There are also four "milking" cells to each set. The latter, it may be mentioned, are cells kept charged in constant readiness to be put on to any defective cell, and bring it rapidly up to full potential.

At Davies-street there have been certain improvements and perfected arrangements lately introduced by the resident engineer, Mr. Foster, to which some special attention may be directed. Users of accumulators generally, and station engineers where batteries are employed in particular, will be interested in these details of battery maintenance.

We may first, however, describe the manner in which the cells are washed out while in use. All secondary batteries have a certain tendency to short-circuit by the fall of dirt or sediment. The whole battery is regularly washed out three times a year, and this operation is so arranged that it can be done while the cells are in operation and with a minimum waste of acid. The apparatus consists of an acid-pump and two lead tanks. These tanks are placed so that one overflows into the other, the last, if necessary, into a lead sink leading to the drains. When the cells are to be washed, an extra supply of acid at the ordinary specific gravity is mixed in the lower tank. The cell to be cleaned is stirred up well and the muddy acid is siphoned off to the first tank, while more clear acid is pumped in from the second tank. The muddy acid siphoned off passes through two filters—one of copper gauze and the other of two thicknesses of the best flannel. The acid is already fairly clear in the first tank, where the rest of the dirt settles as the clear acid rises and overflows into the second tank; from here it goes once more to wash out and fill up a second accumulator cell, and so on for the whole battery. The cells can thus be washed out while in use; the acid is used again and again; the plates are but little exposed to the air, or washed by water only. The last two conditions are very necessary to keep the plates in really good condition; if exposed to the air the charged plates rapidly heat and disintegrate by occlusion of gas, and if washed by water alone the plates have a tendency to sulphate. Apart from this, the comparative ease and economy of washing show this to be the best method of cleaning the cells.

The improvement mentioned above relates to the separators of the accumulator plates. Battery plates require to be firmly kept apart at a constant distance by separators made of some substance not affected by the acid. Ebonite or xylonite are the materials usually supplied, but they are curiously uneven in the quality of resistance to the action of acid, and sometimes become gradually eaten away till they no longer can support the weight of the plates. Again, the mud which falls clogs in the interstices, and tends to short-circuit the cell, instead of tending to drop away from all possibility of contact. Moreover, negative and positive plates touch on the same separator in the old form, and the slightest coating of mud leads to some discharge, and eventually to a bad short-circuit.

The improved separator is made of glazed vitrified earthenware in short lengths, sufficient to hold four plates.



Improved Battery-plate Separator.

The sides are so fashioned as to throw off any coating of mud that may fall. These separators are placed on the bottom of the cell end to end. Two rows carry one kind of plate only—say, the negatives; another two rows carry the positives, and there is thus no possibility of connection between them. They are easy to fix, move, or clean, and are, of course, impervious to the acid, while as they are made in short lengths they do not easily break. These separators are kept apart at the right distance in a very simple manner by strips of window glass placed between them. The bottom of the cells now generally in use are covered with pure rubber sheet; this is costly, and is also troublesome to clean. The strips of window glass which take their place with the improved separator are cheap, and can easily be brushed or washed clean. The plates are kept apart from each other by three glass tubes. Altogether this arrangement seems a sensible and practical improvement, and we shall expect to see it widely adopted.

In the station every care has been taken for the comfort of the working staff. They have a mess-room, complete with bunkers and a kitchen range. Mr. Foster has also opened a reading-room and library, which the men use after working hours, and which contain the daily papers, technical papers, and technical books.

(To be continued.)

MOTOR GEARING FOR ELECTRIC TRAMCARS.

In discussing the question of motor gears for electric traction purposes, the term "gearing" is best taken in its widest possible sense as implying a mechanical connection between the motor spindle and car or truck axle. Perhaps, fortunately in this case, it is quite possible to do so by reason of the vague meanings usually attached to the word "gear," which is made to imply not only a system of mechanism to increase or decrease the speed of the second motion shaft as compared with that of the prime mover, but also the simple connections between driving and driven axles running at the same angular velocity. There are, that is, three possible methods of gearing—increasing, decreasing, or preserving the same speed; in engineering language—gearing up, down, or level.

When applied to street tramway traction by means of electric motors, the possibilities of gearing are seen to be limited at once, so far as this country is concerned, in the first place, by the restriction placed by the Board of Trade upon the velocity of street traffic—that is, upon the speed in revolutions per minute of the tramcar axle, from 60 to 120 revolutions being practically the limits within which it is permissible to work.

The average power which is required to keep a car in motion is not very great; at the outside, on bad roads with heavy grades and a full load of passengers, it should not exceed 12 h.p. to 20 h.p., whilst on ordinary lines it will not reach half this amount. Even with a 20-h.p. motor, however, the speed of motor axle usually employed is much in excess of that named as practically the highest limit of the car axle, and therefore the gearing or connection between the two axles has hitherto been designed, as a rule, for decrease of speed.

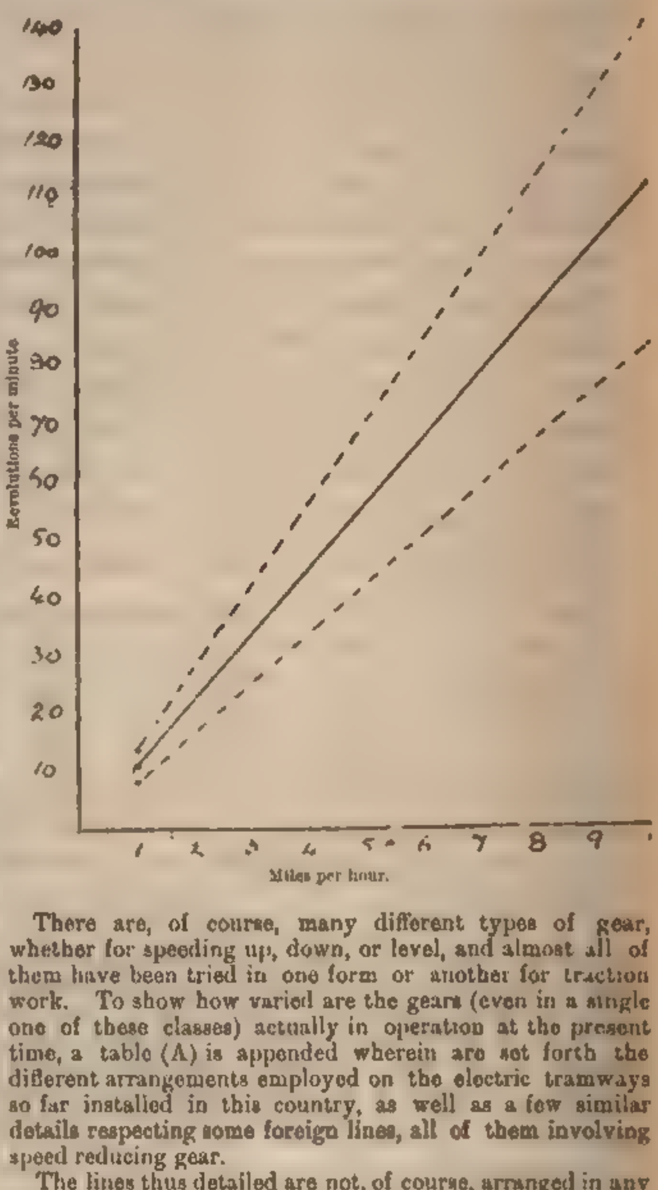
This may be largely due to the fact that electric motors were at first machines built with armatures designed to run at high speeds in a weak magnetic field, and although a brief examination into the development of electric tramway motors generally will be found to show continual progress towards a reduction in armature speed, combined with increased strength of magnetic field, for similar outputs, we are not yet sufficiently advanced (if, indeed, it should prove actually possible) to secure quite as great an electrical efficiency in these latter types as in the former ones. The total or commercial efficiency may not, however, differ very materially in the two cases, because the loss in motor efficiency is to a large extent made up by the gain secured when mechanical gearing between the motor and car axles can be avoided.

The limitations of speed attainable by the car axle are of course easily reckoned, but it may be useful to set them out in tabular form to serve as a reference, and thereby save trouble of calculation. The following table therefore shows the number of revolutions per minute of a given size of wheel at different horizontal velocities.

Revolutions per Minute.

Inches diam.	Miles per hour 1	2	3	4	5	6	7	8	9	10
24	14	28	42	56	70	84	98	112	126	140
26	13	26	39	52	65	78	91	104	117	130
28	12	24	36	48	60	72	84	96	108	120
30	11·2	22·4	33·6	44·8	56	67·2	78·4	89·6	100·8	112
32	10·5	21	31·5	42	52·5	63	73·5	84	94·5	105
34	9·8	19·7	29·6	39·5	49·4	59·2	69	79	88·9	98·8
36	9·3	18·6	28	37·3	46·7	56	65·3	74·7	84	93·4
38	8·8	17·6	26·5	35·3	44·2	53	61·8	70·7	79·5	88·4
40	8·4	16·8	25·2	33·6	42	50·4	58·8	67·2	75·6	84

The diagram shows these limits in a graphic form, the dotted lines representing the revolutions of a 24in. and 40in. wheel respectively, and the full line those of a 30in. wheel—the size usually employed in tramcar working. Even with the wheel of smallest size—24in.—which obviously is a minimum dimension for ordinary work, the greatest speed in revolutions does not exceed 140 per minute; whilst an inspection of any electric motor manufacturer's price-list will show not only that, roughly speaking, speed and output vary inversely with one another, but that the speeds of highly efficient motors, suitable for traction work, so far as the power required is concerned, are seven or eight times as much as that of the smallest wheel above mentioned. The necessity, therefore, of a speed-reducing gear is obvious, if we are to aim at high electrical efficiency; the only points for decision are those which involve the type of gear chosen, since it might be easy to lose in the latter all the advantage gained by the superior efficiency of the motor itself.



Miles per hour.

There are, of course, many different types of gear, whether for speeding up, down, or level, and almost all of them have been tried in one form or another for traction work. To show how varied are the gears (even in a single one of these classes) actually in operation at the present time, a table (A) is appended wherein are set forth the different arrangements employed on the electric tramways so far installed in this country, as well as a few similar details respecting some foreign lines, all of them involving speed reducing gear.

The lines thus detailed are not, of course, arranged in any strict chronological order, although as a matter of fact they fall into a kind of sequence simply by grouping together first those employing a double-reduction gear, and secondly, those which use a single reduction only. The former came first into use, owing largely to the reason already given—the high speed of motors—and it has only been during the past three or four years that the introduction of slower-speed motors made it easy to obtain an equal, if not greater, total efficiency by doing away with one set of gears, whilst still preserving a high electrical efficiency in the motor.

The average reduction with the double gear is nearly 9 to 1, the single reduction being, of course, about half this amount. Before discussing the various types of gear, there are one or two inferences—confessedly imperfect and incomplete however—which may be drawn from the figures in the table. Looking at the matter quite generally, it is evidently advisable to keep down both the speed and weight of motor and gear, whilst preserving, or even increasing the output in brake horse power. If, therefore, the speed and weight be multiplied together, and the product divided by the output, the resulting figure for each line may be looked upon to some extent as a figure of merit, obviously the smallest being the best. Approximately these figures are as follows.

TABLE A. GEARED MOTORS.

Line.	How reduced, and amount.	Type of gear.	Speed of motor (revs. per min.)	Weight of motor.	Weight of gear	B.H.P. of motor.
Bessbrook	double : 8·3 to 1	1. Straight spur. 2. Sprocket wheel and chain.	850	24cwt.	3cwt.	20
Blackpool	double : 12·57 to 1	1. Straight spur pinion and internal wheel. 2. Sprocket wheel and chain.	800	9cwt.	2cwt.	4–5
Birmingham	double : 6½ to 1	1. Double helical. 2. " "	700	20cwt.	3cwt.	20
Portrush	double : 7 to 1	1. Straight spur. 2. Chain and sprocket wheel.	600	11cwt.	2cwt.	7
Brighton	double : 9 to 1 single : 8 to 1	1. Link leather belting. 2. " " Worm gearing.	1,100	4cwt.	—	4½
Southend ...	single : 3½ to 1	Straight spur.	600	16cwt.	2cwt.	15
Ryde	single : 4·67 to 1	Chain and sprocket wheel.	500	11cwt.	—	7½
S. Staffs...	single : 4 to 1	Double helical.	400	15cwt.	1½cwt.	15
Leeds	single : 4·78 to 1	Straight spur.	450	18cwt.	2cwt.	15
Guernsey	single : 4·4 to 1	Straight spur.	600	18cwt.	—	7
Marseilles	single : 5 to 1	Straight spur.	450	17½cwt.	—	17
Panama	single : 4·75 to 1	Chain and sprocket wheel.	420	17cwt.	—	7½
Hobart	single : 4·4 to 1	Straight spur.	420	19cwt.	1cwt.	12½
Thomson Houston standard equipment	single : 4·78 to 1	Straight spur.	450	17·5cwt.	215lbs.	15

S. Staffs.	453	Ryde	850
Marseilles	507	Panama	945
T. H. Standard	570	Portrush	1,114
Leeds	600	Bessbrook	1,147
Hobart	700	Brighton	1,650
Southend	720	Guernsey . .	1,714
Birmingham ...	805	Blackpool	1,760

The position in such a "scale of merit" of the Guernsey equipment—the motors of which are probably working very much under their real power—shows, however, that many other points beside those named must be considered, not the least important being that of prime cost. High speed motors are, as a rule, not only more efficient in operation, *quâ se*, but decidedly cheaper to build than those designed for very low speeds: they should weigh less, and therefore involve less dead load and waste of propelling energy. The item of cost alone may vitiate the value of any such list as that just given. What may be aimed at—if it be possible for outsiders—is rather to arrange the systems according to the "revolution—hundredweight—sovereign" per horse power for a given electrical efficiency.

Then, again, the question of overload is highly important: by cutting down the weight here and there, a large saving may be made on the dead load; but when the inevitable strains come on—both in the armature and fields (and probably electric motors are nowhere else strained so much or undergo such changes of load as when employed for traction work) the result is that breakdowns become frequent, and the expense of maintenance therefore greater. It may be very wise policy to carry a little extra weight in the motor, if only to be prepared for maximum loads under bad conditions.

But however imperfect the above figures may be, they certainly serve to show considerable development in the more recent lines as compared with those first established, such as the Blackpool, Brighton, Bessbrook, and Portrush tramways. Taking, for instance, the extremes of the so called "scale," the Blackpool motors, with a speed of 800 revolutions, only give an output in horse-power of ·45 their weight in hundredweights. The South Staffordshire motors, on the other hand, have a speed half as great, whilst the ratio of output to weight is as much as ·92. The enormous advances made of late years in the design and construction of electric motors could not be more clearly illustrated than by such figures as these. Moreover, they serve to show the superiority of single-reduction gear as compared with that involving an intermediate shaft between the motor and car axles. The margin which is given by a design similar to that used on the South Staffordshire line is much in excess of any saving to be effected, either in the first cost of double reduction motors, or in their dead-weight and efficiency, with consequent economy of operation. Even taking the Birmingham line, which is the most modern of those employing double-reduction gear, the percentage of output to weight is less than with the South Staffordshire motors, being ·87, as compared with ·92, whilst the speed of the former is nearly twice as great. Dependent, of course, upon the extensive, and therefore cheap, manufacture of standard low-speed motors, together with economical production and transmission of electrical energy, there can be no doubt that a single-reduction type of gear is at present the most satisfactory for general use. The next step—viz., that of driving direct, and abolishing all intermediate connections by mounting the motor armature upon the car axle, or coupling them together with side rods—has been already taken with some degree of success, but it is questionable whether for the low speeds possible on tramways in this country the saving thus effected by doing away with mechanical losses would make up for the reduced electrical efficiency of the motor.

(To be continued.)

DESIGN OF ALTERNATING-CURRENT MOTORS.*

BY EMIL KOLBEN.

(Concluded from page 395.)

III. *Determination of the Magnetism Current and the Load Current.*—The well-known method of finding the idle current of a transformer applies equally well to motors also. If y, y_1, y_2, Fig. 8, are the mean lengths of the magnetic circuits and B, B_1, and B_2 the $\sqrt{\text{mean}^2}$ values of the induction densities in the field, the air-gap and the armature, H and H_2, the corresponding values of the magnetising forces, then the total number of ampere-turns required on the field of a motor of $2p$ poles at no load will be

$$i\,N = \frac{10}{4\pi}\,2p\,(2y_1 B_1 + H y + H_2 y_2);$$

hence the $\sqrt{\text{mean}^2}$ value of the magnetising current

$$i = \frac{1{\cdot}59\,p\,(2y_1 B_1 + H y + H_2 y_2)}{N} \quad . \quad . \quad (16)$$

* From the *Electrical World*, New York.

We see at once that i will reach a high value if high frequencies (such, for example, as used generally in American practice) are employed, for then the number of pairs of poles must at least have the value of $p = 5$, in order to come down to reasonable speeds. The chief factor, of course, is the air-gap reluctance, and as the gap is, from mechanical reasons, the same for a certain size of motor, whether it is run on high or low frequency circuits, the magnetising current will increase with the number of poles, and consequently with the frequency.

The idle current, or the current which the motor takes when it is running free, will be but little different from the magnetising current, as the actual work of w watts performed by the motor due to friction and copper losses in armature and field will be very small. If $i_1 = \frac{W}{E}$ is $\sqrt{\text{mean}^2}$ current due to this work, then $i_2 = \sqrt{i^2 + i_1^2}$ is very closely equal to i, as will be seen at a glance from Fig. 9. If the value of i_2 should differ considerably from the calculated magnetising current, then the design of the motor is faulty, for then there must be false currents induced in the armature conductors, which become a source of loss of energy, and by this the value of i_1 and with it that of i_2 will increase largely. This fact will be also at once evidenced by a considerable slip even at no load.* The full-load current, I, can now be found in the following manner. The magnetising current at full load, although somewhat smaller than at no load, on account of the reduced induction densities in the iron, may be taken equal to i without an appreciable error. The useful energy delivered by the motor is

FIG. 8.

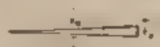


FIG. 9.

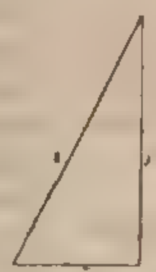


FIG. 10.

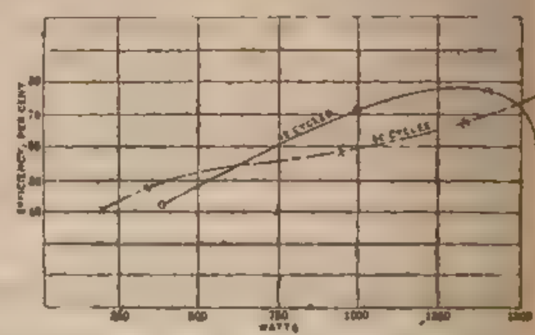


FIG. 11.

W watts and w_1 the energy due to copper and friction losses. From these we find the true working current at load :

$$I = \frac{W_1 + w_1}{E},$$

and the actual current will result from the combination of I and i according to diagram, Fig. 10, and its $\sqrt{\text{mean}^2}$ value will be :

$$I = \sqrt{I^2 + i^2} \quad . \quad . \quad . \quad . \quad . \quad (17)$$

With this value the section of the field wire and the copper losses in it should be accurately verified.

IV. *Motor Efficiency.*—The total efficiency may now be found exactly by calculating the following losses :

1. The hysteresis loss, w_h, and eddy-current loss, w_e, from the known maximum induction densities, B and B_2, from the cubical contents of the iron in the armature, c and c_2, cubic centimetres, and from the frequency, n, thus :

Hysteretic watt loss :

$$w_h = a\,n\,(c\,B^{1.6} + c_2\,B_2^{1.6})\,10^{-7}$$

where the Steinmetz hysteretic coefficient, a, has the value $a = 0.003$ for good sheet iron.

Eddy-current watt loss :

$$w_e = C\,n^2\,(c\,B^2 + c_2\,B_2^2)\,10^{-11}$$

where the eddy-current coefficient, C, has the value $C = 0.004$ for sheet iron of five millimetres thickness.

By careless design, a considerable loss may be caused through the leakage field producing strong eddy currents in the field conductors themselves and in the solid iron or metal frame holding the iron discs together.

2. The copper loss in the field from the full-load current, I (see equation 17), and the resistance of the field winding, R :

$$w = I^2 R.$$

3. The copper loss in the armature from equation (10) :

$$w_1 = u\,\frac{E_1^2}{R}.$$

4. Friction losses due to the bearings and the air resistance at full speed to be easily estimated or taken from tables of mechanical text-books.

Fig. 11 gives an idea of the variations of the total motor efficiency with the output. The two curves are plotted from results of test on an Oerlikon 2-h.p. single-phase motor designed to work on a circuit of 42 cycles.

* These false currents are inevitable with single-phase motors, as the field strength is fluctuating. With three-phase motors the *field is entirely homogeneous* and false currents are thus obviated.

ON THE ESTIMATION OF ELECTRICAL RESISTANCE BY MEANS OF ALTERNATING CURRENTS.

BY F. KOHLRAUSCH.

A paper on the above subject, of which an abstract is given in the *Foreign Abstracts* of the Institution of Civil Engineers, is published in the *Annalen der Physik und Chemie.* The following is the abstract :

The author has investigated the conditions and limits of accuracy in the measurement of resistances by his telephonic method. The apparatus is similar in principle to the metre-bridge, but the wire is three times the usual length, and has a resistance of 10 ohms. Two extra coils of 45 ohms can be inserted symmetrically, or both on one side of the bridge. The telephone is in connection with the two ends of the wire, and, in place of the usual battery, the secondary of an induction coil is in circuit with the rider and the middle terminal of the bridge. The coil generally used by the author has a solid iron core. The resistance of the primary is five ohms, and that of the secondary 30 ohms. It is driven by an accumulator, the interruptor being a platinum point dipping into mercury under distilled water, and making about 85 vibrations per minute. The platinum point is in connection with the negative pole. In measuring a resistance the rider is adjusted until the sound of the induction coil is no longer audible in the telephone.

The author arrives at the following conclusions. Under favourable circumstances the error by this method is less than one part in 10,000. If the position of minimum sound is indefinite by reason of polarisation, or of the self-induction or the capacity of the apparatus, then the middle point between two positions of equal intensity of sound gives the relation of the resistances with tolerable accuracy. The construction of the coils is a matter of some importance. Up to about 1,000 ohms, the ordinary bifilar winding gives good results, but at 4,000 ohms the error may be about ½ per cent., and the position of minimum sound is ill-defined. This error increases, according to Wien, with the square of the capacity and of the resistance. Coils made after the method of Chaperon, in which the successive layers are wound in opposite directions, are free from this defect, and may be used up to 30,000 ohms. It is better to use several small

coils instead of a single large one in making up a rheostat of high resistance, on account of the greater capacity of the apparatus in the latter case. Thus five coils of 1,000 ohms in series gave a well defined minimum, whereas with a single coil of 5,000 ohms the telephonic method was almost worthless. By the use of an adjustable condenser suitably arranged, the disturbing effect of the capacity of the coils may be in a great measure eliminated.

The error due to polarisation decreases as the resistance and the surface of the electrodes is increased. With polished electrodes, when the product of the area in square centimetres by the resistance in ohms amounts to 250 or more, the probable error from polarisation does not exceed 1 per cent. But the author recommends that polished electrodes should only be used for special purposes. They should be thickly platinised until a matt surface is obtained. Such electrodes, of from 10 to 35 square centimetres area, used with resistances of from 50 to 8 ohms, may be considered free from polarisation, the error being under 0·1 per cent. In dealing with very high resistances it is necessary to keep the induction coil at a distance from the measuring apparatus, and to place both telephone and bridge in such a direction with regard to the lines of force that their disturbing effect may not appear. In measuring the resistance of a fluid, the influence of the electrostatic capacity of the containing vessel may be felt, and the same effect may be observed when the resistance is immersed in a water-bath. In both cases the difficulty may be got over by the use of an adjustable condenser. A bath of petroleum was free from this objection. If the resistance to be measured is considerable—*e.g.*, 100,000 ohms—disturbing noises, due to static charges, are heard in the telephone. These may frequently be sufficiently reduced by connecting some point on the circuit with the earth. In such cases the telephone may show signs of being unsymmetrical—that is to say, on reversing its connection with the bridge, or changing the direction of the induced currents, the position of minimum sound may alter, even as much as 4 per cent. This error is to be eliminated by reversing the telephone, and taking the mean of the readings. It is probably due to static charges, and was most marked when using an induction coil with a core consisting of a bundle of wires.

OUR COALING STATIONS AND OUR TELEGRAPHS.

The following has been sent to the *Pall Mall Gazette*:

"Sir,—A dead set is at present being made against the Queensland Government for sanctioning a contract which throws the first section of the proposed Pacific cable into the hands of a French company, thus placing the line at the mercy of French operators in case of war.

"No one, however, seems to recollect the extent to which the Imperial telegraphic communications, especially those with our coaling stations, pass through the territory of foreign Powers, none of which has any particular reason to wish well to England.

"Thus, of the existing cables to Halifax, Nova Scotia, and Esquimalt, only one—namely, that from Heart's Content to Cape Ray—passes through Newfoundland at a sufficient distance inland to be guaranteed from the attacks of foreign filibusters. This line communicates by two cables with Aspey Harbour, Cape Breton.

"Of the other lines, four in number, laid from Placentia, Newfoundland, to Sydney Harbour, Cape Breton, two pass between the French islands of St. Pierre and Grand Miquelon, in very shallow water, and two actually land in St. Pierre, which also commands most of the existing lines to the United States. The land line between Halifax and Esquimault, west of Winnipeg, is for hundreds of miles within easy reach of the United States border, and quite unprotected against filibusters. From Halifax to Bermuda there is only one line.

"In the West Indies our coaling stations have not one single direct telegraphic communication through British territory. Kingston, Jamaica, communicates with the Admiralty by lines passing through Cuba (Spanish territory) and the United States. Its communications with the other West India islands pass through Puerto Rico (Spanish) and St. Thomas or Santa Cruz (Danish); a very roundabout line of communication with the Transatlantic cables existing in the line stretching from Kingston to Panama, and thence by a line stretching north along the Pacific coast through all the Central American republics, Mexico, and the States, and south through all the South American republics to Buenos Ayres, this, and the South American cable to Europe *viâ* Madeira (Portuguese), Lisbon (Portuguese), and Vigo (Spanish). Antigua is dependent on lines passing through the French island of Guadeloupe or the Danish islands of St. Thomas or Santa Cruz. Roseau (Dominica) is isolated between Guadeloupe and Martinique (French): all the Southern West Indies, including the Imperial coaling station at Castries Bay (Santa Lucia) and Trinidad, are dependent on (*a*) a line passing through Martinique and Guadeloupe (French); (*b*) on a second *viâ* Trinidad to the Danish islands of Santa Cruz and St. Thomas; (*c*) on a roundabout route over the Brazilian lines to Rio and Europe, touching French territory at Cayenne, and Dutch territory at Paramaribo.

"As regards South Africa, with its great coaling station of Simon's Bay, and West Africa, with its bay of Sierra Leone, close to that strategic point of Cape Verde, to which Admiral Aube's plan attaches such importance, our telegraphic communications are as follows: (*a*) By a line stretching through Lisbon, Madeira (Portuguese), St. Louis (French), Dakar (French), and the harbour whence they hope in future to control the great trade routes converging on Cape Verde, to Sierra Leone, thence by Grand Bassam (French), and Monrovia (Liberian) to the Gold Coast, and Lagos, touching French territory *en route* to Assinie (?), if not also at Kotouna and Porto Novo; (*b*) for South Africa the cable extends from Madeira through the Canary Islands (Spanish) to Cape Verde, San Thomé, Loanda, and Beryuella [? Benguella] (all Portuguese), and thence to Simon's Bay.

"The same is the case with the East Coast route to South Africa, as the cable from Aden, after leaving Zanzibar, touches Portuguese territory at Mozambique and Delagoa Bay, skirting the French Comoro Islands, before reaching Natal.

"As regards India and the further East, including Australia, we have only one fairly safe route in the cable stretching *viâ* Gibralta and Malta to Port Said, thence down the Red Sea to Aden, and thence to Kurrachee, landing, however, *en route* at the Kuria Muria Isles, which are not fortified, and are at the mercy of any hostile cruiser. This is the only route by which in time of war we could communicate with Bombay, Point de Galle, and Singapore, and the section between Malta and Port Said is one very liable to be interrupted by volcanic disturbances. All the other lines to the East pass either through Russian or Turkish territory, whilst every line in the Mediterranean save that between Gibraltar, Malta, and Port Said is thoroughly under foreign control. Between Singapore and Hong Kong the line touches the French settlement of Saigon.

"Our communications with Australia and New Zealand are entirely dependent on the line stretching from Singapore to Port Darwin, and passing through Dutch territory in the Java land lines, thus materially affecting our control over the coaling stations of Thursday Island and King George's Sound. Aden and Mauritius communicate by a line not yet completed, which was all but being carried through Madagascar, and the French port of Diego Suares.

"In short, every coaling station in our Empire may be said to be in communication with the Admiralty by lines which either pass through foreign territory or are at the absolute mercy of foreigners, for it is obvious that in case of war with France it would be impossible to repair even the section from England to Gibraltar, still less that from Gibraltar to Malta, without fighting a naval battle to protect the repairing ship, and that such an interruption could be readily effected cannot be for a moment doubted. Trusting that the attention which has been called to the state of our Imperial telegraphic communication by the action of the Queensland Government may result in a thorough enquiry into the whole of this important subject, I am, Sir, yours obediently, "H. Reade.

"24, Lower Sloane-street, S.W., Oct. 25."

THE

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CONTENTS.

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THE PACIFIC CABLE.

Twice within a measurable period we have discussed this question, both times calling attention to it before any cable was made for or laid in this direction. The position of affairs has now changed, and the various people concerned in the matter are realising the fact that unless action is at once taken, it will be too late to obviate a grave defect in our cable system. In future years England will curse the very name of the cable authorities who have led to the existing system. The history of cable-laying, whenever it may be written, will show that such curses have been amply deserved. Before briefly recording the facts let us at once say that, considered from merely a commercial point of view, and not from the national point of view, the conclusions about the best system of cables may not accord with those we venture to put forward. Our view has always been that calculations as to cost and maintenance might be made from the purely commercial side, but that the system, while providing for commercial wants, should also be laid with a view to Imperial wants, and the difference in cost and in maintenance, if greater in the latter case, should be borne by the Imperial and Colonial exchequers. That is our thesis, and if the system as at present to be found is not in accord with these views, the sole reason has been and is that such a system does not meet with the views of the heads of the cable companies in Old Broad-street. We have not a word to withdraw from our article of November 25 last year—but why go over old ground? What exactly is required? The following are our conclusions on the subject:

First.—The mother country should be able at all times and under all circumstances, whether at peace or war, to correspond with her colonies without the communications being open to the inspection of foreign countries.

That proposition seems to us to be somewhat axiomatic and undeniable, but the fact remains that it is totally impossible. The mother country cannot communicate, putting aside Canada, with any single Eastern or Western colony except by the courtesy of a foreign country. Quite recently the fraternisation of the French and Russian navies has led to forcible political articles on England's unpreparedness in case of a coalition war. Sleeping with a pipe in one's mouth over a powder magazine is, comparatively speaking, safety to the condition of England at the present moment. Without troubling about matters outside the pale of this paper, we may say that in the event of war the probability is that English-owned cables would be of greater value to our enemies than to us. Examine the maps and see; do not take our word. France, Spain, Portugal, Russia, Turkey, Egypt do not love us, and only tolerate us because the hand is still heavy and cannot easily be shaken off. All our connections with the East are by these countries. By the courtesy of these countries we can communicate direct, but not otherwise.

Second.—This proposition has already been stated to the effect that the difference in initial cost

and cost of maintenance of a system suited to Imperial needs over that suited solely to commercial needs should be borne by the Imperial and Colonial exchequers.

In the case of the proposed Pacific cable the commercial return would be less than if the system was in short lengths, calling at different ports; hence the necessity of subsidies. If we had a cable or cables direct to Canada, and from Vancouver to Australia, these, with the Canadian land lines, would enable us to communicate direct to Australia and to any other Eastern colony, because the Eastern Extension and the South African lines radiate from Australia westwards, so that from London we could get directly through to Canada, Australia, and India. Hitherto the stumbling-block has been the demand of the cable companies. Colony has been played off against colony. The Press, both Colonial and English, has undoubtedly been educated to support certain demands, and no one seems to have formulated the true position. Have we now done so? If our propositions are granted, an examination of the books of the cable companies would show that not only have the lines been extravagantly worked, but systematically so; that they really earn higher dividends than have been paid, and so existing tariffs and subsidies are not warranted by the true facts of the case. We trust, therefore, that those interested in England being able to communicate directly with her colonies will examine more closely into the matter, and urge public opinion to make itself felt in this direction.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

LIFTING WATER BY ELECTRICITY.

SIR, — In reply to your correspondent "J. G.", in this week's issue of the *Electrical Engineer*, there would be no difficulty in pumping the water from the well to the cistern by means of an electric pump, consisting of an electromotor and a three-throw ram pump, which could be coupled direct by spur gearing, or the pump could be belt-driven from the pulley of the motor. The power required at the motor would be about 2½ h.p. The power would be obtained from a dynamo driven either by the engine or waterwheel, and transmitted to the motor by cable. The power required at the dynamo would depend upon the size of the cable used, with due regard to economy in cable. The power required at the engine would be about 4 h.p., or at the waterwheel about 5 h.p. to 6 h.p. These figures are based upon the assumption that the pump is worked 24 hours per day. If it were only worked for 12 hours per day it would require double the power mentioned above.

We will be glad to give your correspondent any further information he may require if he will write to us direct.—Yours, etc., WYNNE AND BARNARD.

Newcastle-on-Tyne, October 28, 1893.

REVIEWS.

Continuous-Current Dynamos and Motors. By FRANK P. COX, B.S. The W. J. Johnston Company, New York.

We have often to eulogise American technical publications, because the authors have a directness which most English authors lack. They understand that a vast mass of detail matter about minutiæ is in elementary books out of place, while the English author must try to say a word about everything he knows to show he knows it. This book, however, while very good, hardly comes up to our standard of what an American book should be, perhaps because it includes too much. The chapters devoted to indicator diagrams and steam-engine calculations might with advantage be left out. They assume the student to have a knowledge which, this being an elementary book, he has probably yet to acquire. Taking the contents of the book as given, the matter is very fairly and sensibly given. Young students not yet familiarised with abstract formulæ, are assisted by the translation of formulæ into numerical examples. We are not quite sure that we agree with Mr. Cox in some of his deductions, but then, with all due respect, it is just as well to find opinions differing, otherwise books would become stereotyped and progress abolished. With certain minor exceptions, then, we should say that Mr. Cox has produced an elementary work of a valuable character, containing much valuable information given in an able manner. Especially useful will be the chapters in which he analytically and numerically considers the design of armatures and field magnets. It is just such numerical examples that show the young reader how to use the varied formulæ he meets with in his reading.

Town Councillors' Handbook to Electric Lighting. By N. SCOTT RUSSELL, M.Inst.C.E. Biggs and Co.

One of the chief difficulties in the progress of electric lighting is in the lack of elementary knowledge of would-be users. Town councillors hear of the electric light and see it on every hand, but the exact procedure to obtain it for their constituents, its properties, its probable cost, and its strong and weak points are unknown. It is for the purpose of supplying elementary information in these directions that Mr. Scott Russell has prepared this little handbook. In it he tells the reader of the law in its relation to electric lighting—how to and when to apply for a provisional order or a license. But far beyond this, he gives in simple language a slight insight into applied electrical matters; and, still more important to the councillor, discusses the question of rival illuminants. No matter how unfair it is to compare directly the cost of one illuminant with the other when indirect losses occurring with the one and not with the other are never considered, this comparison will be made. Happy for electrical work that the comparison will not swamp it, as lighting by electricity when general can be made to come as economically to the householders as can gas. Mr. Scott Russell has done yeoman service in preparing this little book, which will undoubtedly be of great service to all those connected with local administration.

SOME INTERESTING PECULIARITIES OF THE ALTERNATING ARC LAMP.*

BY THOMAS SPENCER.

Although arc lighting by means of direct currents has been practised in this country for nearly 15 years, it is only quite recently that an attempt has been made here to utilise the alternating current for that purpose, although it is a historical fact that the very first attempts made to introduce arc lighting for street illumination was by means of such a current. I refer to the Jablochkoff candle. Jablochkoff found that he had to use an alternating current to make his two carbon pencils, which composed his candle, burn away equally. Since Jablochkoff's time there has been a great deal of work done in Europe, and especially in Germany, where greater progress has been made in the electrical sciences than any other part of the eastern continent, towards utilising the alternating current for arc lighting, and I have the pleasure of showing you one of the latest productions of that country (both as to lamp and carbon to be used with it) this evening. The lamp itself, though, being an American production, it being manufactured by the Helios Electrical Company, of Philadelphia,

* Paper read at the meeting of the Electrical Section of the Franklyn Institute.

under patents of the German company of the same name. This lamp I will speak of later.

As I said before, it is only quite recently that alternating currents have been utilised for arc lighting. The first systematical attempt of the sort was, no doubt, that of the pioneers of alternating currents in this country, the Westinghouse Electrical Company, of Pittsburgh, Pa., when they put upon the market their well-known alternating series system. This was, no doubt, brought about by a circumstance, and that circumstance was the invention by Mr. William Stanley, who was then consulting electrician for that company, of a wonderful constant-current alternating-current dynamo. This machine I look upon as one of the most beautiful in its performance of anything in the whole range of electro-dynamic machinery. It was my pleasure to be so situated as to have the handling of two of the first machines of this kind sent out by the company—the performance of these machines were simply wonderful. I have time and time again switched one of these machines from full load—that is, 60 arc lamps, each taking 45 volts—to a dead short-circuit, with only a variation of a half ampere in the current, and this without any mechanical regulation. I would say, in passing, that with this machine the only thing to be feared was an open circuit, and that the safe way to run the machine was dead short-circuited.

The principle on which this machine worked was very vaguely understood for some time, the inventor himself having a very complicated explanation, based on armature reaction, but no doubt the correct explanation is this: The machine has an armature of the tooth form, on which there is wound quite a large amount of wire, and as a result the E.M.F. generated by the machine is quite large, but on account of the way the armature is constructed there is a large self-induction. These two factors being so great the actual resistance in the current becomes insensible in comparison with them, so the current is practically independent of the resistance in circuit; or, in other words, [illegible]

This can more clearly be seen from the following equation, where

c is the current;
E the E.M.F.;
R the total resistance in the circuit, including the resistance of the arcs of the arc lamps;
L the coefficient of self-induction;
$p = 2 \pi n$ where n is the frequency.

$$c = \frac{E}{\sqrt{R^2 + L^2 p^2}}.$$

Now, if E and L are very large in comparison to L R, we have

$$c = \frac{E}{Lp};$$

or the current is constant, no matter what the external resistance may be, providing it is not too large.

With such a machine the Westinghouse Company thought they had solved the problem of arc lighting by means of alternating currents, but in this they were mistaken; in fact, this was really the easiest end of the problem, and although this machine has now been known for over three years, this system has made little progress, due to the fact that these lamps did not come up to the standard set by the direct system in common use.

The fact is, that here in this country an alternating-current arc lamp has been studied entirely in those lines on which a direct-current lamp was found to give the best results, while European practice shows plainly that a treatment entirely different should be followed.

Let us study the arcs formed by the two kinds of currents; first, as regards the distribution of their illuminating power.

Let Fig. 1 represent the two carbon pencils in a direct arc lamp, where the upper pencil is supposed to be positive. Suppose we take a, the arc, as a centre of a circle, and suppose we plot off on each radii the candle-power in the direction represented by it. Now, if we trace a curve through all the points thus found, we have a curve, as shown in Fig. 1, from which we see that nearly all the light is thrown down in the direction a b. This is due to the fact that nearly all the light from an arc lamp comes from the crater on the positive carbon.

Fig. 2 shows the curve for an alternating arc, which you see is altogether different from the first curve, there being four wings instead of two, as in the first curve, and these wings are shorter.

This distribution of light, of the alternating arc, has always been looked upon as a failing, for the light represented by the two upper wings is usually thrown up and wasted, especially if the lamp is out of doors. This defect has been in a great measure remedied in the lamp before

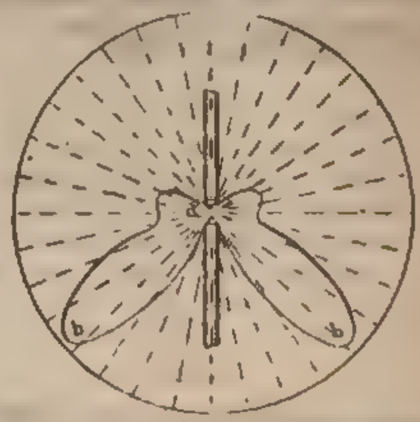


Fig. 1.

you, by making the lamp focussing—that is, making the arc remain always in the same place, and using a white reflecting plate close above the arc. This plate will reflect something like 80 per cent. of the light incidenced upon it. There is another point in which there is a great difference in the two currents; it is this: One of the first things noticed about the alternating current was that there was very little arcing at switches where currents of large amperage were broken. This peculiarity was looked upon as a particularly valuable feature, for in the construction of switches the arcing was the principal thing to be guarded against, especially where high voltages were to be broken. I think, with the general introduction of alternating-current plants, this property is not appreciated. One has only to stand and watch the arc that follows a plug

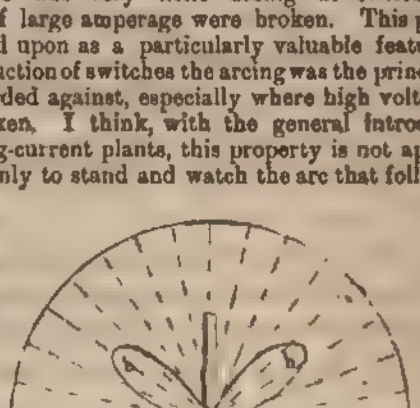


Fig. 2.

switch in a direct arc switchboard, where the voltage is not over 2,500 volts and 10 amperes, and to imagine what the result would be if the alternating current should suddenly acquire the same property, on some of the beautiful switchboards for incandescent lighting of about the same voltage and much larger amperage, when the switches began to be thrown. There has been a great many theories about this property of the alternating current, but it is about settled that it is due to the fact that at a certain instant there is no current flowing to keep up the temperature of the vapour through which the current is flowing sufficient to maintain a strong, hardy arc, and as a result it is easily broken. Now this property, although it is just the thing we want, as far as switches are concerned, is far from desirable when we

come to use the alternating current for arc lighting. It is evident from what has been said that an alternating arc is much less hardy than that of a direct current of the same current density. We see, therefore, that it is a mistake to follow the lines of the direct system in devising an alternating system. What is desired is to get as much heat generated as possible in the flame, so as to keep up the temperature of the vapour through the time when the generation of heat practically stops for the instant. This is best illustrated by Fig. 3, where *a a a* is the current curve and *f f f* the temperature curve of the flame for the same instants, and *c c c* the minimum temperatures, which the flame reaches. Now, *c c c* will be larger the larger the current, and the arc will be more hardy.

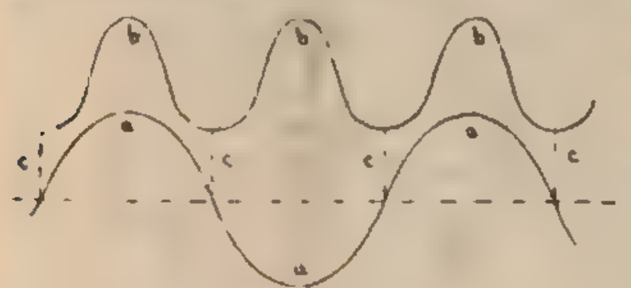


Fig. 3.

So it would seem that the only way to produce a good alternating arc lamp is to use a large current, but a large current means a large candle-power, unless we lower what is called the counter E.M.F. of the arc, or the drop in E.M.F. which occurs at the crater itself. If we refer to Fig. 4, where A and B are the carbon points, the distance between them being exaggerated for convenience, and suppose the drop in potential plotted from one point to the other, assuming A the positive carbon, we find for the direct system, at the point *a*—that is, at the crater—that there is a sudden drop of the potential to a point marked *b*. This drop is what is known as the counter E.M.F. of the arc. For the remaining part of the distance the drop is more gradual, and varies as the current. This is the part due to the drop in the flame itself. So it is apparent that if we could reduce the counter E.M.F., leaving as large a loss of energy in the flame as possible, we would get an arc which would be much less affected than with a smaller current, at the same time without any larger output in watts for the lamp. This has been done in the lamp before you by the use of a special low-voltage carbon, which allows this lamp to give an illuminating effect with 28 volts and 10 amperes, equal to about that given by a 45-volt seven-ampere direct-current lamp. Referring again to the counter E.M.F., I would say that there has been a great deal of controversy over

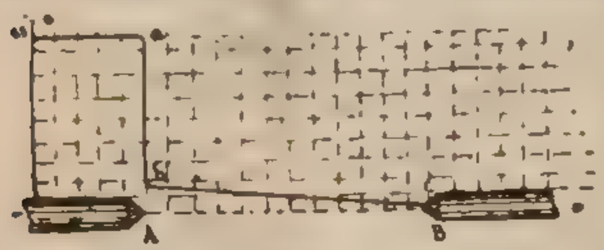


Fig. 4.

whether such a thing really existed. I myself am one of the party who believe in its existence. In fact, there is a strong current setting in the direction of that belief. I myself have been convinced that there was a real E.M.F. in the arc by studying the alternating arc itself; in fact, there are reactions in the arc which could only be explained by the existence of a counter E.M.F. A gentleman in England, whose name I have forgotten, has recently tried an experiment of heating a carbon juncture in a hydroxygen flame, and was able by this carbon thermopile to get quite a difference of potential between the two carbons. He claims that his results were such as to account for the counter E.M.F. of the carbons had been raised to the temperature of the arc. Also quite recently Silvanus Thompson has tried quite a number of experiments bearing on this subject, and has come to the conclusion that the E.M.F. is the result of the energy which disappears as latent heat in the volatilisation of the carbon in the crater.

There is another peculiarity of the alternating arc which is the most serious objection to it, from a commercial standpoint, and that is the noise made by the arc. Even this has been attacked and so overcome that it is no longer the objection it was in the early forms of lamps using alternating currents. The cause of this noise is due to the constant variation of temperature of the flame, as I have described already, which produces an expansion and contraction in the surrounding air. The result is a musical note depending on the frequency of the current. That there is a real rise and fall, even in the light given out by

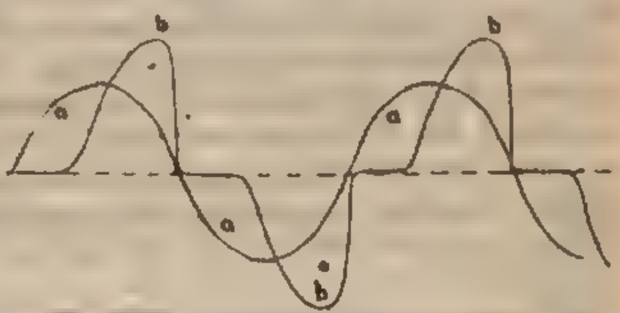


Fig. 5.

the arc, can be shown by moving a white stick, or, better, a short piece of white wire moved back and forth rapidly near the lamp, when the white band, caused by the preciseness of impression in the eye, will be observed to be broken up into bands, showing that the light is varying with the alternations.

The noise is, I find, a function of the form of the current curve. This came under my notice in trying to substitute a choking coil in place of a resistance to absorb the excess E.M.F. above what was wanted at the arc. I noticed that the noise was considerably increased by the coil over the resistance. You can see that this is the case by the experiment I have arranged before you, which is so wired that either the resistance or coil can be used. You will observe that when the lamp is burning on the coil, there is considerable more noise than when the resistance is in circuit. The reason why this is the case will be explained by referring to Fig. 5, where let *a a a* be a simple curve of sines, which is very near the case, with a well-designed alternating dynamo. Let this curve be deformed by the current represented by it, passing through a choking coil with iron. The deformed curve will be something like the curve, *b b b*, due to the lack of constancy of the permeability, and to hysteresis in the iron. If we look at this

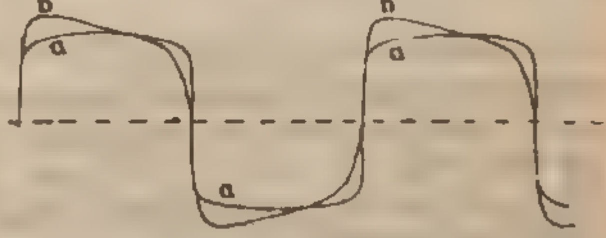


Fig. 6.

curve we will notice an abrupt rise in it, which means a sudden rise of temperature in the flame; or, in other words, we would have a sort of explosion, and as a result this form of current curve would be more noisy. There is no doubt but the form of the current curve, which would be the best as far as sound is concerned, is that of the simple sine curve, for in this curve the current rises gradually, and sinks away gradually.

One thing which puzzled me for some time was that I found that a choking coil, which contained no iron, even made more noise than when a resistance was used. As there was no changing permeability or hysteresis in the arc, the cause for this increased noise was not quite so apparent. The explanation, no doubt, lies in the fact that no machine gives a true sine curve, but in most cases the curve is symmetrical as regards the rise and fall, as will be

seen by the curve *a a a*, Fig. 6, which is supposed to be the form of curve given by the dynamo. Now, a choking coil without iron would deform this curve to the form shown in the curve *f f f*, on account of the change of phases which it would bring about in the different harmonics which make up the compound wave coming from the dynamo.

It is found that when the frequency is reduced the noise is greatly decreased: for instance, lamps burned by means of the current supplied by some dynamos recently turned out by the Westinghouse Electric Company, which have a frequency of 7,200, practically made no noise. On the other hand, Mr. Tesla, by going the other way—that is, by raising the frequency above the audible point—made a perfectly quiet arc, but as high frequency introduced so many other objectionable features, I hardly expect to see this method very extensively introduced.

There is what you might call, still, a mechanical way by means of which the noise can, in a measure, be reduced, and that is by running with a short arc. The reason for this is self-evident, for by so doing you keep the flame well inside the hot walls of the carbon, which do not fluctuate as much in temperature as does the flame; as a consequence the surrounding air is not so much affected, and the result less noise.

I will say, in closing, that an alternating arc lamp is something very much to be desired, as it forms one of the links in a chain towards which all electrical engineering is now drifting. I refer to the designing of a central station so that all kinds of electrical work can be done by one kind of current, which can be supplied by one kind of machinery at the central station. Not as now by several different kinds, as I saw to-day, a station using at least five different kinds of dynamos. That the alternating current is to be the current settled upon no one will deny, on account of its great flexibility. Therefore, the alternating arc lamp has a great future before it, even greater than the series arc has had in the past. It therefore gives me pleasure to exhibit to you to-night a lamp which, I believe, embodies in its construction the most advanced idea in alternating arc light engineering.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE III.

(Concluded from page 401.)

A company was formed in 1864 to carry out the works. A weir was constructed during favourable seasons of low water, in 1864-5 and 1865-6, across the river, which is about 500ft. wide. The fall immediately at the weir is not great, but there are rapids below it, and by placing the turbine house above the weir and constructing a subaqueous tailrace 620ft. long, a fall was made available, varying from 15·6ft. in low conditions of the river to 13·7 in high conditions. The turbine house contains three turbines of 200 h.p., 200 h.p., and 300 h.p. The turbines are axial flow pressure turbines with vertical shafts, driving a common horizontal shaft by bevel wheels.

Two hundred horse-power is taken directly from one of the turbines and transmitted to a factory on the hill above the turbine house by a steel shaft 550ft. long. From the same shaft also about 22 h.p. is taken off by a subsidiary wire rope transmission, which passes down the right bank and then across the river to a pulp factory. There remain about 530 h.p. to be dealt with by the main wire rope transmission, which passes directly across the river to the left bank, and then along the river bank up the stream on the left shore.

As to the turbines, there is nothing of special interest, except that they are constructed with a partition dividing them into two rings of buckets. During low conditions of the river, when there is a good fall, the outer rings of buckets only is used. When the fall is smaller, both rings are used. This compensates a little for the variation of normal or most economical speed of periphery, with variation of fall. The turbines make 34·28 revolutions per minute. The turbine regulating sluices are under the control of a relay governor. An auxiliary 6 h.p. turbine works the main sluices of the inlet chamber. There is a friction brake on the main shaft of the turbines which is thrown into action by the governor if the speed exceeds a certain limit. Then, if a rope breaks, the friction brake comes into action and stops the turbines. Connected with the brake is an apparatus for determining the power transmitted by the ropes. But the author has not been able to learn whether this is satisfactorily used.

We have now to deal with the principal wire-rope transmission across the river. It has been seen that the turbines drive by bevel wheels a horizontal shaft, each turbine being capable of being disconnected by putting its bevel pinion out of gear. The horizontal shaft makes 80 revolutions per minute, and carries at its driving end two principal rope pulleys of 14·75ft. in diameter. From these pulleys two cables cross the river in a single span of 385ft. to a pulley station in the river at the left bank, where the direction of the transmission is changed by bevel gearing, and thence the transmission passes up the left bank of the river.

The two principal rope driving pulleys are not keyed on the horizontal driving shaft, but run loose on it. Between them is a strong cross head keyed on the shaft, carrying bevel wheels on studs, which gear into bevel wheels fixed to the driving pulleys. If the tension in the two driving cables are the same the bevel gearing would have no action. But if there is any difference of tension, the bevel wheels permit one driving pulley to rotate faster than the other, so that equality of tension in the ropes is re-established. This differential gear has not, so far as the author is aware, been elsewhere adopted. Provision is made for keying either driving pulley on the shaft, in the event of one rope breaking and the power having to be transmitted through the other rope. The differential gear is then out of action.

The gross power in the horizontal driving shaft in the turbine-house is about 530 h.p., or, allowing for friction, say 500 effective horse-power to be transmitted to the factories, or 250 h.p. for each rope. Either rope is capable of transmitting at any rate a large fraction of the whole power temporarily if the other rope is broken.

This power is delivered by the ropes at the change station on the left bank. At that station about 22 h.p. are taken off by prolonging the second shaft of the bevel gearing and a subsidiary rope transmission. The remaining 478 h.p. is transmitted along the left bank to the first intermediate pulley station, at a distance of 370ft., by a pair of cables. Thence to the second intermediate station, distant 345ft., by another pair of cables. At 455ft. further is another or second change station, at which the direction is again changed by gearing. Thence the ropes pass to two further intermediate stations.

From the second intermediate station an underground shaft carries about 27 h.p. to 10 small workshops, and from the second change station, and the third and fourth intermediate stations, cables are carried back across the river to factories on the right bank. From the first shaft at the second change station, about 110 h.p. are distributed partly by a special rope gear, partly by vertical and underground shafting, to four factories, one of which is the large Mosersche Gebaude; and, from the second shaft of this station, a steel shaft transmits 200 h.p. to Scholler's wool factory. Between the turbine house and the second change station the cables consist of 80 wires 0·042in. diameter, in eight strands of 10 wires each, with a hemp core; diameter of rope 1·06in.; speed of rope, 62ft. per second. Smaller ropes are used in other parts of the transmission. The distribution has been described rather fully, because it is essential to learn how far wire rope transmission can be adapted to complex conditions, where many consumers require power.

It would appear that the rather complex arrangement of differential gear and double cables were intended originally to meet the case of having to drive by a single cable while the other cable was broken or under repair. It appears that under present conditions one cable would not be strong enough to transmit the whole power which is utilised; on the other hand, experience has shown that there is no necessity to duplicate the cable to avoid accidental stoppages. The total length of principal transmission is about 2,000ft.

The Schaffhausen installation has been an entirely successful undertaking, and has very greatly benefited the industries of the town. Some particulars of the extent to which the power has been utilised may be interesting.

Year.	Number of renters of power.	Average total h.p. supplied.	Rent from power. £
1867	13	121	345
1868	13	150	585
1869	14	180	730
1870	15	234	830
1871	16	293	1,215
1872	17	337	1,510
1873	17	350	1,650
1874	19	483	2,300
1875	21	527	2,520
1876	23	595	2,800
1877	23	597	3,000
1878	23	610	3,060
1879	23	610	3,040
1880	24	623	3,120
1881	23	634	3,100
1882	23	641	3,200
1883	23	639	3,240
1884	22	641	3,080
1885	23	632	2,880
1886	23	639	3,080
1887	23	641	3,300

The charge for power in 1887 varied from £4 16s. to £6 per horse-power per annum.

The total cost of the works appears to have been reckoned at

* Howard Lectures delivered before the Society of Arts.

£29,360 originally, and this, by writing off, stood at £24,664 in 1887.

As to the working of the system it appears that experience has proved that there is a greater loss of power in transmission in wet and frosty weather than was originally expected. When the maximum power is being used, there are oscillations of the ropes which drive the machines at irregular speed. The spinning factory suffered most from this and ceased to take power. This has led to the construction of a new power station and the adoption in the new works of electrical instead of wire rope transmission.

In some excellent lectures which were delivered before this society in 1891 by Mr. Gisbert Kapp, the method of transmission by wire rope is compared with the method of transmission electrically very much to the disadvantage of the former. "Till recently," said Mr. Kapp, "rope transmission held the field absolutely, not because it was perfect, but because there was nothing better. Now, however, we have something better in electrical distribution, and the flying ropes are being steadily replaced by the electric conductors." The use of the word "replaced" conveys a wrong impression. The wire ropes have not been replaced at Schaffhausen by electric cables, but an additional power station has been erected, and an electric transmission has been placed beside the rope transmission. It happened accidentally that at a visit of the author to Schaffhausen, about a year and a half since, the rope transmission was working while the electric transmission was stopped, having been temporarily disabled by a lightning accident. It seemed desirable to ascertain from Messrs. Rieter what view they took of the prospects of wire rope transmission, looking to the fact that they had the opportunity of knowing the results of the working of rope and electric transmission side by side. They were good enough to send answers to some enquiries. They say that at Schaffhausen the rope plant is expected to do more work than was originally provided for or intended; also, it was the first large installation of the kind and had some defects, which experience has shown can be remedied. Electric transmission, they say, has also been found to have some inconveniences. They, however, do not think that electric transmission will compete seriously with rope transmission for short distances, such as that at Schaffhausen, as I understand them; on the other hand, for long distances, they admit that electric transmission has the advantage.

Transmission at Tortona in Italy.—As early as 1876, and apparently independently of Hirn, an Italian engineer* erected a small cable transmission, worked from a waterwheel, at Tortona. There is a single span of 400ft. The waterwheel drives the first rope pulley by gearing, with a ratio of 19 to 1. The rope speed is 50ft. per second. The most interesting points about the transmission are (1) that, in spite of the disadvantages of gearing, and the smallness of the power transmitted (7 h.p. or 8 h.p.), the loss in normal conditions of working appeared to be only 6 per cent., and (2) that the substitution of water power and rope transmission for steam effected an economy of 60 per cent.

The Installation at Fribourg, Switzerland.—A company was formed in 1870, partly to acquire and work the forests owned by the town of Fribourg, partly to utilise and sell water power, and partly to carry out a scheme of water supply. This was to some extent a scheme in advance of any previous one, because the company acquired land which they proposed to lease to industrial undertakings, including in the lease a right to a supply of power from the plant of the company.

A dam, 40ft. high, was built across the River Sarine, near the town, in a ravine where it was not possible to construct factories. The company, therefore, acquired some level land about 300ft. above the river, adjoining a railway and otherwise well adapted for factories. The factories were to be worked by power transmitted by wire ropes from the power station at the river.

With the minimum flow of the Sarine and an effective fall of 35ft., 1,700 h.p. could be obtained. Provision was made for two turbine houses containing eight turbines of 300 h.p. each. Only two turbines have actually been constructed—one driving pumping machinery for water supply, the other driving a rope transmission. The turbines are Girard turbines, running at 74½ revolutions per minute. The turbine for transmission drives a horizontal shaft at 81 revolutions per minute by bevel wheels. This carries a 15ft. pulley with single groove driving the cable, by which power is transmitted to the plain of Perolles. The principal rope transmission consists of five equal spans of 500ft. each. The total distance to the sawmill, at which power is first taken, is 2,500ft., and the difference of elevation is 268ft. The rope pulleys are all 15ft. in diameter, and the rope is 1·08in. in diameter. The rope consists of 90 wires, ·072in. in diameter, in 10 strands of nine wires with hemp cores. The speed of the rope is 62ft. per second. At the sawmill a subsidiary transmission works a railway for carrying timber and using 50 h.p. This has a rope ⅞in. in diameter. From the shafting of the sawmill another subsidiary rope transmission takes 120 h.p. to railway carriage works, at a distance of 930ft. From the carriage works there is a further transmission of 60 h.p. by a ⅞in. rope a distance of 1,600ft., and thence by ropes ⅞in. in diameter to a foundry and chemical factory. The power is sold at the rate of 200f., or £8 per horse-power per annum.

It was at Fribourg that Messrs. Rieter introduced the plan of employing ropes, previously stretched, so than they should not require to be shortened after being some time in use. The ropes are stretched 0·71 to 2·6 per cent. of their length by a machine which compresses them radially, while a longitudinal tension is also applied.

The Installation at Bellegarde.—In 1872 a company was formed to utilise the water power of the Rhone, at Bellegarde, not very far from Genova. The total power of the river which is available is estimated at 12,000 h.p., but the original project, which was on a very large scale, has been only partially carried out, and the works have not been financially successful.

The water is led from a point above the Perte du Rhone, through a tunnel 1,800ft. in length, to the Valserine, near its junction with the Rhone. A turbine house has been erected, with five Jonval turbines, on a fall of 36ft., developing 630 h.p. each. The power is sold at 200f. to 300f., or at £8 to £12 per horse-power per annum. Quarries of deposits of phosphate of lime, a wood pulp factory and paper mill, a copper refinery, and other works, are driven by the turbines.

The turbines are in a gorge. The wire ropes are led from pulleys on the turbine shafts to a pulley station, distant 120ft. vertically above the turbines, and 200ft. horizontally. The total distance to the phosphate factory is 3,000ft.

The horizontal shafts driven by the turbines carry each two pulleys, 18ft. diameter, with ropes 1·28in. in diameter, consisting of 72 wires, ·081in. in diameter, with a hemp core. The rope speed is 66ft. per second. The greatest span at Bellegarde is 630ft.

The Installation at Gokak, in India. The most recent and one of the largest telodynamic transmissions has been erected at Gokak, in the southern Mahratta country, in India. This installation has been carried out by Messrs. Escher Wyss, of Zurich.*

The river falling over a high cliff has motive power enough for many industries. At present three turbines of 250 h.p. each (750 h.p. altogether) have been erected to drive a cotton mill of 20,000 spindles. The water taken at 2,300ft. above the fall is led by a channel to the edge of the cliff, and thence in a 32in. wrought-iron pipe. The pipe descends about 110ft. vertically on the face of the cliff, and then is inclined at about 30deg. to the horizontal. In the turbine house the three turbines are supplied by three 24in. branch pipes. The total fall acting at the turbines is 180½ft. The turbine wheels are 67in. in diameter, and they turn at 155 revolutions per minute.

The turbines are action or impulse turbines with partial admission; and they have horizontal axes, each turbine axis carrying a wire-rope driving pulley. There is a sluice valve, worked by hand, and a throttle or disc valve, controlled by a governor, to each turbine. The governor is a relay governor, in which a belt on speed cones drives differential gearing connected with the throttle-valve. If the governor moves the belt to either side of its central position the differential gear comes into operation, and opens or closes the throttle valve.

The shafts of the turbines carry wire rope pulleys 11½ft. in diameter. The rope speed is 93ft. per second; the ropes are 1in. diameter. At the top of the cliff is a rope station, with carrier pulleys 198ft. and 220ft. above the turbine shafts. The pulley for the tight side of belt is 11½ft. in diameter, that for the slack side is 8ft. in diameter. The distance from this station to the mill is 432ft., and there is an intermediate carrier station for the slack side of the belt, which would otherwise foul the ground. There are, of course, three ropes, one to each turbine. The installation was set to work in October, 1887.

Advantages and Disadvantages of the Telodynamic System.—The telodynamic system is adapted for transmitting and distributing power to distances of a mile or more, which are large compared with the distances to which power is ordinarily transmitted by shafting and similar means. On the other hand, it cannot seriously compete with electrical transmission in cases where the distance to be covered is reckoned by many miles. With this limitation it may be noted that—

1. It has the peculiar advantage that it transmits the mechanical energy developed by the prime mover directly without any intermediate transformation. In electrical distribution, a double transformation is necessary—a transformation into electrical energy by a dynamo, and retransformation back into mechanical energy by an electric motor. This double transformation involves waste of power and increase of capital expended.

2. The efficiency of transmission to such distances as those at Schaffhausen is undoubtedly very great; it is uncertain whether a similar amount of power could be distributed to an equal number of consumers electrically with as little waste of energy in the process.

3. The telodynamic transmissions which have been at work, some of them since 1864, have actually worked continuously, without serious stoppage, and have only failed to return an adequate profit where they were undertaken on a scale too large for the amount of industry requiring to be supplied with power in the locality.

4. Where, as at Bellegarde and Fribourg, the power station is 150ft. or more below the factories driven, the telodynamic system has an advantage over some systems, such as the hydraulic system, that there is no loss of efficiency due to difference of level.

On the other hand, it may be admitted that telodynamic transmissions, simple as they are mechanically, involve considerable cost. The pulley piers require to be lofty and strongly built. The maximum length of span hitherto accomplished is 630ft. at Bellegarde. Experience has also shown that the cost of maintenance is considerable. The cables must be replaced annually, and experienced workmen are necessary to make the long splices in the ropes.

One distinct disadvantage of the telodynamic system is that no means has been found of directly measuring, by numerous or continuous observations, the amount of power delivered to each consumer. So long as the power is distributed to very few consumers, it is possible to assess, with practical fairness, the charge to each, without such measurements of the power. But, in pro-

* N. Ruggeri, *Proc.* Inst. Civil Engineers, vol. l., p. 192.

* *Engineering*, June 8, 1888.

portion, as the consumers are more numerous, the defect of the system in this respect becomes more serious. A recording transmission dynamometer would of course, obviate the difficulty, but the cost of such an appliance is considerable.

It is, in some cases at any rate, a defect of the cable system that the amount of power which it is practically possible to transmit by a single cable is limited. It is not possible by increasing the size of the cable to transmit an indefinitely large amount of power. The cables became too heavy to be manageable, and the pulleys too large in diameter. In the report of the experts advising the town of Geneva, in 1889, the limit for one cable was placed at 100 h.p.; Messrs. Rieter Bros. place it at 300 h.p., and that amount has in fact, been transmitted; no doubt the proper limit varies in different cases.

It is also an inherent characteristic of the cable system that the efficiency decreases rapidly when the distance increases beyond certain moderate limits. On the most favourable interpretation of the experiments the efficiency may be ·96 for 100 yards or 93 for 500 yards, efficiencies remarkably high. But the efficiency falls to 0·60 for 5,000 yards, an efficiency by no means remarkably good.

LECTURE IV.

Hydraulic Transmission.

The practical application of a system of distribution of pressure-water for motive power purposes is due to Lord Armstrong. From the first, Lord Armstrong contemplated a distribution of pressure-water in town areas for the supply of motive power to many consumers. For that purpose the supply of water for motive power purposes may be conjoined with the supply of water for other purposes, the motors being driven by water from the ordinary town mains. In that case no special system of mains for power water is required; but, on the other hand, the pressure is limited to that suitable for ordinary water supply. Or a special system of distribution of power water may be adopted, and in that case it generally proves to be convenient and economical to use a much higher pressure than would be suitable for ordinary water supply. For a long time the installations carried out for the hydraulic distribution of power were of a local and restricted character, and were special systems of the latter kind. Only in a few towns pressure-water for a small number of motors was obtained from the ordinary mains, the price charged for the water being so great that it was preferable, in most cases, to use steam or gas engines.

The advantages of hydraulic transmission for actuating machines which work intermittently, such as cranes, lifts, capstans, and dock gates, were soon obvious. For this particular purpose, it is convenient to use exceptionally high pressure with small mains and comparatively small motor cylinders. Such high pressure hydraulic transmissions were first erected in connection with docks and arsenals. It was only after many years that similar systems came to be applied for power supply over extensive town districts. The conditions under which high pressure systems first achieved success gave them a special character, which imposes definite limitations on their application. The high pressure system is almost exclusively an English system and almost exclusively suitable for working intermittent machines. For ordinary power purposes it is less well adapted. Comparatively recently systems of hydraulic transmission at more moderate pressure have been carried out which are better suited to distribute power for ordinary industrial purposes.

In driving cranes and other intermittently-working machines the fluctuation in the demand on the mains for pressure water is very great. Hence, in developing his system, Lord Armstrong was led very soon to consider the question of the storage of energy. Reservoir storage for systems in which the pressure is very great is not generally possible, because no site sufficiently elevated can be found for the reservoir. Air vessels were considered, but the amount of energy which can be stored in that way is not very great, and there are practical difficulties. The pressure in the air vessel varies with the quantity of water in store, and an air pump must be used to replace the air absorbed and to maintain the air cushion. The invention of the accumulator met the difficulty. The accumulator perfectly answers the purpose of storing such a supply of water under pressure as is required to meet the momentary fluctuations of demand in a system driving intermittent machines.

In an article in the *Mechanics' Magazine*, in 1840,* very interesting now, if its date is considered, Lord Armstrong pointed out that when water is lifted by a pumping engine, it becomes the recipient of the energy expended in raising it. If the same water is used to actuate motors, it renders back the power conferred on it in its descent to its original level, and thus becomes a medium through which the power of the pumping engine may be transmitted to a distance and distributed in large or small quantities as required. Lord Armstrong showed that a continuously working steam pumping engine, of comparatively small size, was capable of doing a large amount of distributed intermittent work, and he argued that this would be more economical than the employment of a number of steam motors to drive each separate machine.

Soon after this, Lord Armstrong invented an hydraulic crane of a type used ever since. The pressure-water acts on a piston, the motion of which is multiplied by reduplicating a chain over pulleys. In 1845 a crane, worked by pressure-water from the town mains, was erected in Newcastle; and in 1848 similar cranes were used by the North-Eastern Railway at their goods station in Newcastle. In 1851 hydraulic transmission was adopted for driving cranes and working dock gates at Great Grimsby, at New Holland, on the Humber, and by Brunel on the Great Western Railway.

(To be continued.)

*See the *Proceedings* Institution of Civil Engineers, vol. L., p. 66.

PHYSICAL SOCIETY.

At a meeting of this society, on the 27th ult., Prof. J. Perry, F.R.S. (vice-president) in the chair,

Mr. E. C. Rimington read a paper "**On the Behaviour of an Air-Core Transformer when the Frequency is Below a Certain Critical Value.**" Taking the ordinary differential equations for two circuits having self and mutual induction, and assuming sinusoidal E.M.F.'s and constant coefficients, the author shows that although the difference of phase between the primary potential difference and primary current is always diminished on closing the secondary circuit, yet under certain circumstances this closing increases the impedance of the primary. With constant potential difference this means that closing the secondary decreases the primary current, a phenomenon not usually observed. The critical conditions necessary for increased impedance are fully worked out in the paper, as well as those under which this increase becomes a maximum. In the case of two identical coils with no magnetic leakage, the critical value of a ($a = \frac{p L}{r_1}$, where $p = 2\pi$ times the frequency, L the inductance of the primary, and r its resistance) is $\sqrt{2}$, whilst that to give maximum impedance is $\frac{1}{\sqrt{2}}$. The maximum increase possible is 15½ per cent. The corresponding values are given for various amounts of magnetic leakage in tabular form, and curves were exhibited at the meeting showing how the impedance, current, power, and magnetising effect vary for different values of a. To test his conclusions, the author made experiments on two coils close together, the observed increase in impedance amounting to 3·2 per cent. In addition to the analytical investigation, the subject is treated geometrically at considerable length. **Prof. Minchin** showed that the impedances might be represented by two hyperbolas, having p^2 as abscissæ and the squares of the impedances as ordinates. These could be readily constructed from the data given. A line representing the primary inductance drawn on the same diagram intersects one hyperbola, showing that the impedance has always a maximum value. By a simple construction the phase angle between the primary and secondary currents could be determined for any given conditions. **Dr. Sumpner** observed that increased impedance on closing the secondary necessarily meant a decrease in the lag of the primary current behind the primary potential difference. **Mr. Blakesley** was pleased to see the geometrical method of such service, and thought it much simpler than the analytical one. The reason why increased impedance on closing the secondary of ordinary transformers had not been noticed was because their lag angles were very large. In a figure published some years ago to represent the actions of transformers the angles he had chosen were such as would make the primary impedance increase on closing the secondary. Giving an expression connecting the primary currents on open and closed secondary respectively, he now showed that to get increased impedance the sum of the lag angles in primary and secondary must exceed 90deg. To get large power in the secondary the primary lag should be nearly 90deg., and the secondary about 45deg. He also pointed out that some of the figures in the paper might be simplified considerably. **Prof. Perry** said he had long had the impression that if a sufficiently small current were taken from the secondary, increased impedance would be observable in all cases, and he quoted some numbers he had given in the *Philosophical Magazine* for 1891, showing a decided increase. **Mr. Rimington**, in reply, said he was not aware that the effect he had now brought forward had been observed previously. The result was completely worked out analytically before using geometrical methods.

Mr. W. B. Croft, M.A., showed an experiment on "**Electric Radiation in Copper Filings,**" similar to those described by Dr. Dawson Turner at the Edinburgh meeting of the British Association. A battery, galvanometer, and glass tube containing copper filings were joined in series. Under ordinary circumstances no current passed, but immediately an electric spark was produced by an electric machine many feet away the galvanometer was violently deflected, and remained so until the tube was tapped. On trying different materials, aluminium and copper seemed about equal, but iron not so good; carbon allowed the current to pass always. **Prof. Minchin** said the phenomena were strikingly like those exhibited by his "impulsion cells," for the moment a spark passed, even at a distance of 130ft., they became sensitive to light. Very minute sparks were capable of producing the change, but by adding capacity to the sparking circuit the effect could be greatly modified. Replying to a question from Mr. Rimington, he said the change was due to electromagnetic vibrations, and not to light emitted by the sparks. **Mr. Blakesley** enquired if lengthening the sparks produced greater effect on the copper filings. **Mr. Lucas** asked if the resistance of a tube ever became infinite again if left for a long time. In reply, **Mr. Croft** said the current sometimes passed before the spark actually occurred between the knobs. He had not left tubes for very long, and had not found the resistance reappear without tapping.

LEGAL INTELLIGENCE.

FRY AND FRANCIS v. ST. JAMES'S AND PALL MALL COMPANY.

Mr. Justice Kekewich on Wednesday heard the action of Fry and Francis v. the St. James's and Pall Mall Electric Light Company, Limited, the question raised being whether the company, under its articles of association, was justified in carrying over from profits £1,000 in each of two years to a fund called the redemption fund, to the detriment of the founders' shares issued by the company. The plaintiffs (Mr. Charles Robert Fry and Colonel George Edward Francis) held, the former two and the latter 10 founders' shares, besides being ordinary shareholders, and they sued on behalf of themselves and the other holders of founders' shares in respect to the distribution of profits, to one-half of which they were entitled. For the year ended December, 1890, a dividend was paid at the rate of 5 per cent., a sum not sufficient to enable founders' shares to come within the distribution; but at the end of 1891 8½ per cent was paid on the ordinary shares, and the holders of founders' shares each received £10. 15s., representing one-half of the surplus profits for the year, and in 1892, besides satisfying the preference shares, 7½ per cent. was paid to the ordinary shareholders and eight guineas to each founders' share. The directors, however, in each of these years carried over from profits £1,000 to a redemption fund, as plaintiffs said, to the detriment of founders' shares, and in favour of the ordinary and preferential shares. The point was, were they justified in so setting aside this sum?

The case for the plaintiffs was argued by Mr. Renshaw, Q.C., and Mr. Whinnie, and for the defendant company by Mr. Warmington, with whom was Mr. Swinfen Eady, Q.C. Their contention was that there was no imputation of *mala fides* on the part of the directors, who had acted on the advice of most experienced persons and in the ordinary conduct of the business of the company. Unless their *bonâ fides* were disputed and a question of *ultra vires* was raised, plaintiffs had no *locus standi*, besides which the directors asserted that the memorandum of association authorised them to act as they had done.

In the result, his **Lordship** said that the point raised in this case was a new one, and raised for the first time, founders' shares being a modern invention, and not yet having attained any technical meaning. The *bonâ fides* of the directors were not impugned, and if it were a question of internal management, according to well known principles and decisions, the Court would certainly not interfere with what the directors had done. They were removable representatives of the shareholders, and entitled to manage the business of the company to the best of their ability. This was not a question of the power of the directors, but one of contract, based on the memorandum of association, and he thought he was bound to hold the holders of founders' shares to be parties to those articles. He could not think their provisions operated to shut the mouths of holders of founders' shares in the way suggested. If their mouths were not so shut, the accounts showed that something of the net profits of the undertaking had not been divided, and ought to have been divided. Such being his construction of the contract, he considered the plaintiffs entitled to the claim they made, and he gave judgment for them accordingly, with costs against the company.

HOERLER AND ANOTHER v. HANOVER CAOUTCHOUC AND TELEGRAPH WORKS.

In the Queen's Bench Division on Tuesday, before Mr Baron Pollock and Mr. Justice Kennedy, the case of Hoerler and Another (trading as C. F. Mumm) v. Hanover Caoutchouc, Guttapercha, and Telegraph Works, was heard. This case raised one of those questions so often arising as to the mode of suing foreign firms carrying on business in this country, but having no place of business in this country. The parties had in June, 1890, at Linden, near Hanover entered into a contract in writing, in which it was stipulated that Mumm should receive a commission of 5 per cent. "on all remitted net amounts" of invoices on the sale of goods of the Hanover Guttapercha Company, to be accounted for every six months, but by a supplemental article, the Hanover Company were "to collect the accounts." The plaintiff's firm carry on business in this country, and the sales were here, but one of the articles of the contract was, "In case of disputes, the firm of Mumm submit to the laws in force in Hanover, and jurisdiction." The action was for the stipulated commission on sales of the Hanover Company's goods by the plaintiff in this country. The history of the litigation which had already taken place was this. The original writ in the action, an ordinary writ of summons without leave to serve it out of the jurisdiction of this Court, was issued in February last. It was served on some one who was deemed an agent of the defendants, the Hanover Company, in Basinghall street. On March 20 an application was made to a judge at Chambers to set aside the writ and service, on the ground that the Hanover Company had no place of business in England, and on the affidavits it was held that the company had no place of business in this country, and consequently the writ and service were set aside. On May 2 an application was made to amend the writ, and make it one for service out of the jurisdiction, and Mr. Justice Mathew having made the order at Chambers, the writ was served at the company's place of business in Hanover. On June 5 an application was made at Chambers before Mr. Justice Wills to set aside the proceedings on the ground that there was no cause of action in this country (the commission not being payable here), and that the special clause in the contract gave exclusive jurisdiction to the Court in Hanover. The learned judge set aside the proceedings on this latter ground, but Mr. Justice Collins had subsequently allowed time to appeal, considering, he said, the point to be one of importance. Mr. Temple Franks appeared on the part of the plaintiff, who appealed, and argued in support of the order to proceed in this country, and urged that the goods were sold and the commission earned in England.

Baron Pollock, in giving judgment, said the main question was one of importance, and required to be decided with consideration — viz., that there being no breach of contract within the jurisdiction of this Court, there was no liability in the foreign firm to be sued in this Court. The decision of the Court of Appeal, however, in "Reynolds v. Coleman," 36 Chancery Division, completely covered this case, it being held in a similar case that the service out of the jurisdiction ought to be allowed when according to the terms of the contract, it ought to be performed in this country. That, he thought, was the true rule, and it applied in the present case. This was a contract with a foreign firm for money to be paid to plaintiff for commission to be earned by him in England. The action was brought for the commission, and there could be no doubt it would be a fit case for service out of the jurisdiction, apart from the clause in question as to jurisdiction. That clause provided that the parties should submit to the laws and jurisdiction of the foreign country. If it had been intended to give the Court in Hanover exclusive jurisdiction it might have been so provided in express terms but it had not been so provided, and it appeared enough to hold that it was intended simply to provide that the parties should not be precluded from the Court in Hanover. That being so, he held that the action might be brought in this Court, and, therefore, that the process ought not to be set aside.

Mr. Justice Kennedy concurred, and observed that the contract was one which, according to its terms, ought to be carried out in England, on the ground that the money would be payable there. On the main question the clause in question was only that the parties would submit to the laws and jurisdiction of Hanover — that is, that the plaintiff would not object to the jurisdiction of Hanover. Judgment, therefore, was given for the plaintiff.

COMPANIES' MEETINGS.

INTERNATIONAL OKONITE COMPANY, LIMITED.

An extraordinary general meeting of this Company was held at Cannon street Hotel on the 27th ult. to consider, and, if thought fit, to pass a resolution to the effect: "That the name of the Company be changed to 'The Okonite Company, Limited'"; to consider and, if thought fit, approve draft alterations in the articles of association of the Company; and to consider and, if thought fit, to pass a resolution to the effect: "That the articles of association, as altered and approved by this meeting, and for the purpose of identification subscribed by the chairman thereof, be, and the same are hereby, approved, and that such regulations be, and they are hereby, adopted as the regulations of the Company, to the exclusion of all the existing regulations thereof."

Mr Samuel Pope, Q.C., who presided, explained that the meeting was convened by the Directors in response to the request of a large body of the shareholders of the Company. At the last general meeting the Directors expressed considerable hope that they would be able so to arrange the business at the Manchester factory that it might be turned from a losing into a profitable concern. They did their best, but they found that in order to put it on a sound footing it would be necessary to appropriate a certain amount of working capital to that department of the business. The branch in America was being conducted at a considerable profit, but the revenue made there was liable to be depleted by any losses which occurred in carrying on the business on this side. That fact and the general financial situation in America had induced both the American and English boards to reluctantly come to the conclusion that the proper course to adopt, if the Manchester factory could not be worked profitably, was to cease business in England. He could not say absolutely, but almost the whole of the English liabilities had been arranged, and the property of the Company here was practically unencumbered. The effect of the amendments to the articles of association would be that the existing Board in England would cease; but a certain number of directors would be elected to study the interests of shareholders in this country. The Chairman concluded by moving the resolutions given above.

Mr. Short, the representative of the American Board, seconded the motion, and explained the methods of the Company in America, and described the effect of the present financial crisis. If the amendments were passed the Company could, he thought, be made a success.

Mr. Shaw moved the following addition to the first amendment—namely, Article 35: "Provided that the funds of the Company should not be expended or lent upon the purchase of its own stock."

Mr. Clements, the agent for the American shareholders, said he held proxies for more than 16,000 shares, and his instructions were to vote only for the amendments as proposed.

Mr. F. L. Rawson objected *in toto* to the amendments being

passed, as the measure would place the Company entirely at the mercy of the American shareholders. It was necessary that it should be carried with a three-fourths majority, and he felt certain that if shareholders on this side were consulted more than the requisite fourth could be obtained to defeat the project. The Americans would then be more disposed to reconsider the first amendment to the article.

Mr Shaw's amendment was seconded and supported, there being a very strong expression of opinion as to the advisability of passing the amendment to Article 35 as proposed. At the invitation of Mr. Clements, however, who undertook to represent everything fairly to the American shareholders, Mr Shaw withdrew his opposition, subject to his right, through Mr. Clements, to forward his reasons to the proper quarter in America. The latter gentleman also engaged to send to America any other objections that might reach him.

The resolutions were then put and carried with a few dissentients.

EASTERN EXTENSION TELEGRAPH COMPANY.

The fortieth ordinary general meeting of the Eastern Extension, Australasia, and China Telegraph Company, Limited, was held on Wednesday, Sir John Pender presiding.

In moving the adoption of the report and accounts, the **Chairman** stated that the gross revenue for the half year ended June 30 last had been £257,980, or £10,998 in excess of that of the corresponding period of 1892; while the working expenses had been £78,229, showing a decrease of £1,052. The usual interim dividends at the rate of 5 per cent. per annum had been paid for the past half year, amounting to £62,500, and the balance of £81,116 had been carried forward, as against £70,271 for the corresponding period of 1892. The second year of the Australian tariff guarantee arrangement expired on April 30 last, when it was found that the loss for the year had been £43,558, as compared with £55,040 for the first year of the guarantee. One half of this loss, or £21,779, had been made good by the guaranteeing governments, and the remainder had been distributed between their Company and its partners in the pool. During the current or third year of the guarantee the loss would, as far as they could at present judge, be comparatively nominal, owing to the additional 9d. that was added to the tariffs at the request of the colonies having come into force January 1 last, and to the abnormally large traffic that was carried a few months ago when the bank reconstruction schemes were being arranged. With regard to the cable recently laid by a French company between Queensland and New Caledonia, its promoters claimed for it that it was the first link of the much talked of Pacific cable between Australia and Canada. It had been laid under a guarantee arrangement with the Governments of France, Queensland, and New South Wales, the two colonies giving a subsidy of £2,000 a year each, and the French Government giving a guarantee of something like £8,000. After the strong opposition which had been displayed to this cable, both in the colonies and on this side, it was not likely to be anything more than a local line, and as a local line it ought to be a small feeder to this Company's system. He might mention a fact which should be a lesson to those who had no experience of cables, and it would afford such persons the opportunity of learning from those who had such experience. Only last week both of the Company's Port Darwin cables became interrupted within a few hours of each other, many hundred miles apart, and but for their third cable to Western Australia the colonies would have been entirely cut off from telegraphic communication. Fortunately, they had a repairing vessel available close by, and within a few days they hoped that both cables would be repaired; but similar troubles, arising from inequalities of the bottom and from coral landing places, would most certainly occur in the Pacific, making it absolutely necessary to provide a duplicate line, with at least two maintenance ships and a large sinking fund obtained from earnings, to replace the cable within a reasonable period. Negotiations had been in progress for a good many years for strengthening the China section of the Company's system, and with this object they had for the last 10 or 12 years been working not only with the Colonial Office but with the Straits Government and Hong Kong. They had endeavoured to obtain a concession with some subsidy for the work they proposed to do.

The motion, which was seconded by the **Marquis of Tweeddale**, was carried unanimously.

MONTEVIDEO TELEPHONE COMPANY, LIMITED.

The annual general meeting of this Company was held on Tuesday at the offices in Gresham House, Old Broad street, E.C.

Mr. Herbert Ward presided, and, in moving the adoption of the report, said that during the year ended July 31 last their net profits amounted to the sum of £6,895, which was about £500 more than the net profits of last year; but it must be remembered that last year's profits showed an increase of £1,622 over the previous year; so that there was no doubt that the Company's operations in Monte Video continued to make satisfactory progress, notwithstanding the prevailing hard times in Uruguay. The strictest economy had been observed in all matters relating to the general working of the Company. The central office building in Monte Video had now become the unencumbered property of the Company, the last instalment of the purchase-money having been paid on March 6 last, since which time they had received regular monthly drafts from the manager. One of the Directors had only just returned from Monte Video, and he was thoroughly satisfied with the manner in which their business was conducted by the manager and his staff, and also with the condition of the Company's property. The number of paying subscribers was now 1,383, showing an increase for the year of 33, and with a return to more normal conditions in commercial circles generally in Uruguay, there was no doubt that number would be substantially increased. The Board had to announce that the committee of the London Stock Exchange granted, on June 12 last, an official quotation to the Company's preference and ordinary shares.

After **Mr C. H. Sandford** had seconded the motion, a long discussion followed, in the course of which **Mr. Lock**, **Mr. Touch**, and **Mr. Praed** found fault with the Directors for not declaring a dividend on the preference shares out of the profits that had been earned, as was done on the last occasion, instead of placing the same to the reserve and depreciation fund.

The **Chairman** stated, in reply, that the Board had been informed that it was illegal to declare a dividend on the preference shares at present.

After some discussion **Mr. Touch** moved an amendment to the effect that the report and accounts be referred back to the Board, in order that they might recommend a dividend of 3 per cent. to the holders of the new accumulative preference shareholders of the Company, they agreeing to lend the amount until the Company was in a position to repay the same, with interest.

The amendment was seconded and lost. A poll was demanded, which resulted in the amendment being negatived and the report adopted. After the re-election of Mr. E. F. Powers, Mr. Jones was elected a director of the Company.

BUSINESS NOTES.

Church-Lighting.—The church of St. Mary at Hill, City, is to be lighted electrically.

Western and Brazilian Telegraph Company.—The receipts for the week ended October 27 were £3,704.

Club Lighting.—The question of lighting the Liverpool Junior Reform Club by electricity is being considered.

Eastern Telegraph Company.—The receipts for the month of October were £61,402, as against £61,069 for the corresponding period.

Queenstown.—The Public Commissioners will shortly have brought before them by a company the question of lighting the town by electricity.

Eastern Extension Telegraph Company.—For the month of October the receipts show a decrease of £1,899 as compared with the corresponding period.

South Africa.—At the Crown Reef the erection of the new 120-stamp mill, of the cyanide works, and of the electric lighting plant is being pushed on with despatch.

Blyth.—A large hotel has been opened in Northumberland-street by the Blyth and Tyne Brewery Company, Limited. It is fitted with speaking tubes and electric bells.

Windsor.—New wires have been laid between the Queen's private telegraph office at Windsor Castle and the borough post office at the corner of High street and St. Albans street.

Castleford.—Mr R. Hammond is to advise the Local Board as to the best means of lighting by electricity, preparing plans, and doing the work to the time of applying to the Board of Trade.

Ipswich.—The petition for the winding up of the Ipswich Electricity Supply Company, Limited, referred to in our issue of the 20th ult., has been adjourned to allow of a meeting of creditors.

Office-Lighting.—Messrs. Drake and Gorham have contracted for the electric lighting of the Rock Life Insurance Company's offices, New Bridge street. There will be 120 lamps of 16 c.p. installed.

Gloucester.—The seal of the County Council has been affixed to an agreement for providing telephonic communication between certain police stations near Bristol and the Bristol telephonic exchange.

Measuring Instruments.—Messrs. Paterson and Cooper have been appointed agents for the sale of Messrs. Richard Freres' electrical and industrial measuring instruments for the United Kingdom.

English Electric Manufacturing Company, Limited.—This Company has been registered with a capital of £5,000, in £1 shares, to carry on business as electricians, electrical and mechanical engineers.

Anti-Sulphuric Enamel.—The "anti-sulphuric" enamel made by Messrs. Griffiths Bros. and Co. is being employed in the central station at Brussels for the protection of metal and woodwork from acid fumes.

Manchester.—The subject of lighting the Assize Courts by electricity has recently engaged the attention of a committee of the County Council. For the present, however, it is considered advisable to continue the use of gas.

Trade Dispute.—With reference to the note on this subject in our last issue, it is stated that the two men arrested on a charge of wilfully removing the fuses connected with electric light installation at the Medley Hotel are not connected with the Electrical Trades Union.

Caldbeck.—The Post Office having decided to erect a new line of telegraph wires from Penrith to Wigton, Annan, etc., the villagers of Caldbeck and Sebergham are making an effort to have telegraph stations established on the line of route.

Elmore Wire Company.—At the invitation of the directors, a meeting of the largest shareholders of the Elmore's Wire Manufacturing Company, Limited, was held last week at Winchester House, E.C. The proceedings were private.

Extension of Premises.—It is satisfactory to note that owing to the rapid increase in Messrs. Drake and Gorham's business, they have found it necessary to extend their offices, as their present accommodation is entirely inadequate.

Towcester.—The inhabitants have been canvassed as to whether they will adopt the electric light. Signatures have been obtained for about 800 lamps from the principal shopkeepers, and Sir T. G. F. Hesketh, Bart., of Easton Neston House, will require 100 lamps.

Partnership.—A gentleman with engineering or commercial experience is required to take an active part in an electric light syndicate in full work. The sum of from £1,500 to £2,000 is required. Applications to be sent to Mr. George Ashdown, 56, Gresham-street, E.C.

Tender Accepted.—The tender of Mr. C. Dennis, of Bury, has been accepted for the brickwork, boiler seats, etc., required in the fixing of two Lancashire boilers and one set of Green's economisers at the Lancaster electricity works, Morton street yard, for the Electric Lighting Committee.

City and South London Railway Company.—The receipts for the week ending October 29 were £848, against £889 for the same period last year, or a decrease of £41. The total receipts for the second half year of 1893 show an increase of £257 over those for the corresponding period of 1892.

Wrexham.—The electric light and power company are about to apply to the Board of Trade for a provisional order to authorise them to supply electricity for public and private purposes in the borough of Oswestry, and to do all the necessary work to supply the town with electric power and energy.

Electric and General Investment Company, Limited.—The directors have declared an interim dividend on the capital paid up on the ordinary shares of the Company at the rate of 10 per cent. per annum for the six months ending November 30, 1893, the dividend to be payable on and after December 1 next.

Meeting of Creditors.—At the London Bankruptcy Court on Tuesday, an adjourned meeting was held of the creditors under the failure of Messrs. Day and Young, mechanical engineers, of Bath and London, whose accounts show total liabilities £27,505, and assets valued at sufficient to provide a small surplus.

J and J Robertson, Limited.—This Company has been registered, with a capital of £10,000 in £1 shares, to acquire the business of cycle manufacturers, makers of gas engines, and general machinists now carried on by William Robertson, James Robertson, and two others at Eccles, Lancashire, under the style of J. and J. Robertson.

Fulwood.—At a meeting of the Local Board the clerk read a letter relating to telephone communication with Mr. Jones, the water manager. The letter stated that the communication could be had for the low term of £13. 10s. per annum for three years. If they wanted the exchange they could have it for £23. The offer of £13. 10s. was accepted.

Canterbury Electricity Company, Limited.—This Company has been registered, with a capital of £50,000 in £5 shares, to carry on business as electrical engineers and electricians, manufacturers of electrical appliances, etc. The first signatories are B. Broadhurst, G. E. Zeden, F. E. Beeton, F. Hodson, W. D. Brightman, R. P. Sellon, and A. J. Lawson.

Newcastle.—The question as to the desirability of the Corporation providing electricity in the city is now under the consideration of a committee of the Council, composed of five members each of the Watch, Finance, and Town Improvement Committees. The new Church of England Institute in Hood street is being lighted electrically by Messrs. R. J. Charlton and Co.

Car Accident.—An electric car on the Oregon (Portland) City Tramway line, containing 30 passengers, went through an open drawbridge in Madison street on Wednesday, and was plunged into Carpon River. It is said that 25 of the occupants of the vehicle have been drowned. The car was the first to arrive in Portland from the suburbs, and a heavy fog was then hanging over the city.

Salford.—The minutes of the Gas Committee of the Corporation presented at a meeting this week, mentioned that the town clerk had received the official sanction of the Local Government Board to the borrowing of £32,000 for electric lighting purposes, repayable within 25 years. This amount represented the portion of the £50,000 applied for which it was proposed to expend in the first instance.

Dover Electricity Company Limited.—This Company has been registered by Mr. Sydney Morse, with a capital of £50,000 in £5 shares, to carry on the business of electrical engineers, electricians, engineers, and contractors, suppliers of electricity, and manufacturers of electrical apparatus. The first signatories are B. Broadhurst, G. A. Zeden, F. Hodson, F. E. Beeton, R. P. Sellon, W. D. Brightman, and A. J. Lawson.

Tenders for Bolton.—Tenders are wanted by the 18th inst. for the supply and erection of switchboards, accumulators, connections, etc., for the Gas and Lighting Committee of the Bolton Corporation. Specifications, plans, and forms of tender may be obtained on application to Mr. J. H. Rider, M.I.E.E., borough electrical engineer, Town Hall, Bolton, on payment of £1. 1s., which sum will be returned on receipt of a *bona fide* tender.

Govan.—The Govan Combination Parochial Board met the other day. With regard to the lighting of the new asylum at Hawkhead, a report was submitted which showed that electricity would cost per annum £635, oil gas £282, and Glasgow Corporation gas £200. These figures indicated the total cost, including interest on the price of plant, etc. It was unanimously agreed to adopt the recommendation of the Lunacy Board and light the building with Corporation gas.

Halifax.—At a special meeting of the Town Council it was mentioned that the Gasworks Committee had instructed the town clerk to write to the Local Government Board regarding the application of the Corporation for sanction to borrow £30,000 for electric light works, and to urge the necessity of an early decision. The Gasworks Committee have adopted the proposal of Mr. W. H. D. Horsfall, architect, to prepare plans, etc., for the proposed electric light station.

Burnley.—At a meeting of the Town Council last week Councillor C. Thornber, wished to know if there was any necessity to fix the electric light in the baths? Councillor Lupton replied that it was frightfully hot at night when the gas was lit, and particularly on gala nights. Alderman Burrows said that the electric light had been put throughout the municipal buildings, and now there was an outcry because the working classes were to have a little of the benefit. The motion was passed.

Dewsbury.—The Board of Trade has approved of the system adopted by the Council for the supply of electrical energy for the purposes of the Dewsbury Electric Lighting Order, 1891, subject to the regulations and conditions for securing the safety of the public, and for ensuring a proper and sufficient supply of energy. The site of the old gasworks at Batley Carr is to be used for the erection of the station. Sanction has been received from the Local Government Board for the borrowing of £25,000 for electric lighting purposes.

Chatham.—At a meeting of the Kent Standing Joint Committee at Maidstone, Mr. C. R. Chelfins reported that Chatham police station had now been connected with the telephone, and that the cost would be £10 a year. This was approved of, but an application for the Seabrook lock up to have similar communication with Hythe police station was not entertained, the county surveyor stating that the telephone company not having yet erected a wire between those two places, the cost of a private wire would be a considerable amount.

The Luna Arc Lamp.—An instance of high-tension series arc lighting by a gas engine can be witnessed at the Agricultural Hall where 40 of the Electrical Company's Luna arc lamps are lighting the main hall of the above institution. The current is being supplied by a 50 h.p. Stockport gas engine, driving a Brush high tension dynamo. This is one out of many successful installations carried out by Messrs. Vaughan and Brown, who submit that the Luna lamp is more simple and reliable, and equal in quality to any of its competitors. The price of the lamps is low.

Kensington.—A joint report on electric lighting has been presented to the Special Lighting Committee of Kensington Vestry by Major General Webber, C.B., R.E., and Mr. Philip Monson, the lighting engineer. In accordance with the recommendations therein contained, the Vestry have instructed the solicitor to issue the formal notices in respect to the application in the next session of Parliament for a provisional order to lay down plant, light the streets with electricity, and supply electricity for domestic and other purposes. Notifications were received at a meeting of the Vestry last week for the extension of the mains of the Notting Hill and Kensington Electric Lighting Companies.

Taunton.—The Electric Light Committee of the Town Council reported last week as follows: "Your committee present herewith statement of account showing the sum of £9,716. 8s. 10d., due to the electric light company out of loans account, and £133. 4s. 11d. out of revenue account, making together £9,849. 13s. 9d., after deducting interest at 4 per cent. upon the amount expended by the Council upon the mains. They also present three cheques in discharge of these several amounts—viz., debenture-holders, principal and interest, £7,407. 15s.; electric lighting company, £2,308. 13s. 10d.; out of revenue account, £133. 4s. 11d.; a total of £9,849. 13s. 9d., which they asked the Council to sign." The report having been adopted, the town clerk read out the document by which the property was conveyed from the company to the Corporation, and the seal of the borough was affixed thereto.

Monmouth.—The Mayor remarked at a meeting of the Town Council last week that he had visited London a few days ago and took occasion to call upon the Local Government Board, with the engineers for sewage and electric lighting. Mr. Lailey and the Brush Electrical Company undertook to forward their estimates to him (the mayor), and he had received them by that morning's post. He had no time to go through them very much to be able to give them an epitome of the contents. The object of that meeting was to receive and discuss those estimates, to move a resolution upon them, and if they (the Council) accepted them to make application to the Local Government Board to authorise them to borrow the money. The matter was then discussed in committee, and ultimately the Council decided to apply to the Local Government Board for sanction to borrow £18,000 for the purpose of carrying out the sewerage scheme and electric lighting.

Hawick.—At ward meetings last week one of the subjects discussed was the question of lighting the town with the electric light. The scheme put before the electors was drawn up by Messrs. Mavor and Coulson, of Glasgow, and proposed that the water power at Trowmill, about two miles from the town, should be utilised. The scheme includes the raising of the Cauld by 8in., the erection of a power station and turbine wheel which would develop 100 h.p., which, if found necessary, could be doubled by transferring the plant to Hornshole, about half a mile farther down the river. The estimated cost of the scheme for lighting the entire town, with extension to Town Hall, police office town clocks, stables shambles, sewage works, etc., is given at £9,250 and the annual cost at £835. The cost of lighting by gas at present is given at £841. No decision was come to at any of the meetings, the matter being left in the hands of the representatives for further consideration.

Aluminium Company.—In their report for the 12 months ended June 30, the directors state that the hopes they ventured to express in the last annual report, that a time of greater prosperity for the Company was at hand, have not been disappointed. The Oldbury trading account shows a profit of £7,244 19s. 11d., but this amount was not quite sufficient to meet all fixed charges at the head office, including debenture interest. The volume of the Company's business has increased very rapidly during the last few months, so as to promise a much more favourable result for the current financial year. The directors think this a suitable time to rearrange the capital, and at the extraordinary meeting a resolution will be proposed to write off £4 per share, thereby reducing the nominal value to £1 per share. The directors believe that the present income of the Company will be sufficient to meet all fixed charges, to provide adequately for depreciation, and to leave a balance for dividend on the reduced share capital.

Tenders for Sunderland.—As mentioned in our last issue, the Corporation invite tenders by the 17th inst. for carrying out the work comprised in any or all of the following contracts: (1) Lancashire boilers. (2) High-speed compound engines, dynamos, pumps, steam and other pipes, etc. (3) Motor alternators switchboard, etc. (4) Main switchboard instruments, and connections. (5) Batteries. (6) Insulated cables, etc. (7) Roadwork (*a*) construction of culverts, laying of cast-iron pipes and casings, and building service boxes; (*b*) supply of cast-iron pipes casings, and service box frames and covers; (*c*) supply of stoneware casings and insulators. (8) Copper strip. (9) Gunmetal grip boxes. Those desirous of tendering for any of the above contracts must send in their names and addresses to the borough engineer, Town Hall, Sunderland, and copies of drawings, specification, and form of tender will be forwarded to them on receipt of cheque or order for £2 2s., which will, however, be returned on their submitting a *bonâ fide* tender.

Aberdeen.—A special meeting has been held to consider a proposal which has been made to light Castle-street and Union-street by electricity, the area to extend from the top of Justice-street to Union Bridge. It was decided that eight arc lamps would be sufficient to light the area. The proposal is that the lamps should remain lighted till midnight each evening, after which time the ordinary street lamps would be employed. The plant has already been laid in connection with the installation for the supply of electric light to shops and houses in the central area of the city, and thus no extra expense will be entailed. Mr. Smith, gas manager, will prepare an estimate of the cost of the eight lamps, while Mr. Anderson will furnish a statement as to the quantity of gas that will be saved, in order to show the difference between the two systems. The central electric lighting station will be ready in about six weeks. The experiment will afford an idea of what it would cost to light the whole city by electricity, and will also show the difference in the illuminating power of electricity and gas. The lamps will be placed on ornamental iron pedestals, and none of the existing street lamps will be interfered with in the meantime.

Grimsby.—The Mayor, in consequence of a letter which had been received from Mr. Hammond, moved, at a meeting of the Town Council last week, that an interview with that gentleman should be arranged. The letter having been read, the Mayor said that he was in possession of some information respecting Mr. Hammond by observing some work of his. He had received an invitation from the Mayor of Blackpool to be present at the installation of their system of electric lighting. At Blackpool they had spent £27,000 in the installation although they owned the gas works. He was thoroughly convinced of the practicability of the light. The reason why he should like Mr. Hammond to come and give his views on the question was that he had carried out hundreds of thousands of pounds' worth of work. It was necessary that they should move in the matter in some form. One of the conditions of the order would make it advisable that they should state where the centre or station would be placed, the size of the site, and the streets through which they proposed to lay the mains. It would be a wise policy to have an interview with Mr. Hammond. He proposed that they have such an interview. Mr. Alward seconded the proposition, and after some further discussion the motion was agreed to.

Sale of Plant.—On Friday, 17th inst., Messrs. Wheatley Kirk, Price, and Goulty will sell by public auction on the works premises, the entire contents of the Vulcan Ironworks, Beccles, Suffolk, together with the freehold land and buildings thereon. The fixed and loose plant will include Cornish boiler, 12ft. by 3ft. 2in. diameter; 4 h.p. vertical steam engine; 3cwt. steam hammer, three smiths' hearths, punching and shearing machine, 6ft. plate-bending and 3ft. sheet-bending rolls, fan, 36in. centre wheel lathe; 5½in., 10in., and 14in. centres slide; surfacing and screw-cutting lathes on 6ft., 14ft., and 16ft. beds; 14in. stroke shaping machine, and drilling machines. The new stock and stores will include steel boiler plates, boiler and steam tubes, brass boiler and engine fittings, castings, 6 h.p. portable engine by Garrett, 10 h.p. compound tandem portable engine by Vulcan Company, 2 h.p. vertical engine and boiler, 6 i.h.p. vertical steam engine, 9 i.h.p. vertical steam engine and tubular boiler on foundation tank, 9 i.h.p. and 17 i.h.p. tandem compound engines unfinished, two 6 i.h.p. tandem compound vertical engines, etc. Catalogues and any further information may be obtained at the works, or on application to Messrs. Wheatley Kirk, Price, and Goulty, 49, Queen Victoria-street, London, E.C.

St. Helens.—Alderman Cook, in moving the adoption of the Gas Committee's minutes, at a meeting of the Town Council on Monday, said the Council would observe that the committee recommended the making of an application for a provisional order for the supply of electric light to the borough for public purposes. Their object was to be prepared to take the matter up at the moment it was required. Colonel Gamble wanted to know if the Council would have an opportunity of expressing an opinion as to the area to be supplied by the Corporation. The Town Clerk said the compulsory area would have to be settled by the committee for the advertisement. The present area suggested was Corporation-street, between Hardshaw-street and Shaw street. Mr. Mearns complained of the bad gas. The Corporation had negotiated for 300 tons of coal from some firm at a price not stated. He hoped at the end of the financial year the Gas Committee would remember that the consumers were paying the same price for bad gas as they had hitherto paid for good gas, and that when the provisional order asked for was obtained that electricity would be at once introduced into the borough. Alderman Cook said he did not think the new plant at the gasworks would clash with the electric light, and in reference to the quality of the gas admitted that it was not as good as usual, but it was as good as they could secure in the present state of the coal market.

The Factory Acts.—On Wednesday, at the South Western Police Court, Mr. Denman heard three summonses against the New Electric Light and Power Company, Wellington-road, Battersea, for failing to register the names of young persons employed and to obtain certificates of fitness, and also for obstructing one of her Majesty's inspectors in the execution of his duty. Mr. Jasper Redgrave, one of her Majesty's inspectors, who conducted the prosecution, in answer to the magistrate said he had not summoned the official who was guilty of the obstruction, as the company, in the capacity of occupier of the premises, were responsible for the acts of their servants. The manager refused to permit an examination of the young persons to take place. The inspector so obstructed was called, and said the manager told the lads not to answer his (witness's) questions, and directed them off the premises, adding that if he (witness) did not leave in three minutes he would have him put out. The manager also prevented him from getting near the boys. He told the manager that he would not allow himself to be intimidated. The manager, who was in attendance, regretted the misunderstanding with the inspector. The story, he said, had been exaggerated. The inspector rushed into the factory, and his conduct was such that it demanded an apology. He denied that any obstruction had taken place. Mr. Denman said unless the Factory Act was enforced the whole thing would be utterly worthless. He imposed penalties amounting in all to £10, with £1 7s. [illegible]

Edinburgh.—The Lord Provost's Committee recommended, at a meeting of the Town Council on Tuesday, that parliamentary powers should be asked for the acquisition of additional property adjoining the properties already acquired for the site of the central electric lighting station at Dewar place, and for the closing of a portion of St. Cuthbert's lane, and craved a remit to give it effect. The recommendation was agreed to. The Cleaning and Lighting Committee recommended, at the same meeting, that various streets should be lighted by electricity. Bailie Gulland took exception to the list of streets, and asked why George-street, for example, had not been included. Mr. Mackenzie said Prof. Kennedy proposed that George-street and the streets leading down to Princes'-street should be lighted with the electric light, but the Cleaning and Lighting Committee threw that over. He implored them to decide something soon, as delay was keeping the whole matter up. Mr. Jamieson said the Cleaning Committee had to decide how they could best allocate 130 lamps. Mr. Mackenzie suggested that the matter should be recommitted to the Lord Provost's Committee. It was no use sending it to the Cleaning and Lighting Committee. Bailie Steel protested against the Cleaning and Lighting Committee being blamed for the delay. It was only at their last meeting that they had a plan before them from Prof. Kennedy showing what streets he proposed to light with electricity. It seemed to be the Cleaning and Lighting Committee that was to be blamed all round for everything that went wrong in the town. After further discussion, a motion to approve of the report was adopted.

Tenders for Newport (Mon.).—The Electric Lighting Sub-Committee of the Corporation of Newport, invite, as mentioned last week, tenders for the supply and erection of certain steam-boilers, feed water heaters, economisers, pumps, mechanical stokers, forced draught apparatus, steam, exhaust, and water pipes, condenser tanks, steam engines, driving ropes, oil filter, alternators for incandescent lighting, dynamos for arc lighting, switchboards, instruments, arc lamps and lampposts cables, culverts, surface boxes, junction boxes, converters, converter-boxes, converter-cases, switches, fuses, meters, also day load

plant, to consist of semi-portable engine, alternator and exciter and switchboard for the equipment of the municipal electricity works of the county borough. The plan of buildings map, and specification, with terms and conditions of tender and contract, may be obtained at the offices of Mr. Robert Hammond, M.I.E.E., the consulting engineer to the Corporation, 117, Bishopsgate-street, London, E.C., on payment of £2. 2s., which sum will be returned on receipt of a *bonâ fide* tender. Tenders (sealed and marked "Tender for Electric Lighting") must be addressed to Mr. Albert A. Newman, the town clerk, at the Town Hall, and be delivered on or before Monday, the 20th inst. A new Constitutional club and concert-hall is to be erected on a site at the bottom of Stow-hill, Newport. It is proposed to warm the hall and club premises with hot water on the low-pressure system, and to introduce the electric light for the purpose of lighting. The architects are Messrs. Habershon and Fawckner, of Queen's-chambers, 41, High street, Newport; also of London and Cardiff.

Llandrindod Wells.—A special meeting of the Local Board was held last week to consider whether steps should be taken to establish a gasworks or a system of electric lighting for the district. Mr. Preece (of Messrs. Andrews and Preece, Limited) had made an inspection of the district with the view of explaining to the Board the feasibility of introducing the electric light. Mr. Preece said there would be no difficulty in respect to turning gas out at Llandrindod and replacing it with electricity. At Morecambe the electric light was worked by gas power from one central station, and in that town there was the same difficulty as at Llandrindod Wells—namely, the reduction of the quantity of lights required in the winter season. At Morecambe it cost ½d per unit to generate the light and distribute it into the consumers' houses, while the cost of steam power would be 2d per unit. He considered that few, if any, towns had such a favourable opportunity as Llandridod Wells for introducing the electric light. In answer to questions, Mr. Preece stated that the installation would cost about £2,000, exclusive of land or buildings and the cost of a provisional order. He thought they could charge private consumers about 14s. per lamp per annum, but in a place like that, where the number of lamps used fluctuated greatly, it would be better to have meters. He thought there would be no difficulty in obtaining a revenue of £700 a year. The public lamps could be lighted by electricity at about 15s. per annum. The probable expenditure was calculated, and it was thought that £400 a year would be sufficient to repay the capital and interest of money borrowed to provide the plant and the working expenses. The question was discussed whether a provisional order should be applied for in the next session of Parliament, and the matter was adjourned for further consideration.

Camberwell.—At a meeting last week of the Vestry, Mr. Phillips moved that a statutory meeting of the Vestry should be held on Wednesday, December 6, for the special purpose of considering, and, if approved, of sealing, or authorising to be sealed, a memorial to the Board of Trade for a provisional order under the Electric Lighting Acts, to supply electricity for public and private purposes in the parish of Camberwell, and that an electricity committee of 24 members be appointed. Mr. Wallace said that if the Vestry gave notice, they would be compelled to go on, either themselves or by contractor. The first stage of the installation would cost £50,000, and ere it was completed it would entail an expenditure of £100,000. He confessed he should like to be supplied with further proof of the dust destructor scheme, and he should certainly object to any cost being incurred other than that for the provisional order. Mr Etherington said that if they went to Deptford, where a large electric lighting company had been established under the best scientific authorities, they would find that it had proved a failure. Mr Coward observed that there were some boroughs, such as Bristol, where half the rates were raised from rating and half from investments such as that of the electric light. It appeared to him that they were just at the parting of the ways with regard to the electric light, and that they ought to seriously consider the subject from the point of view of public benefit and public profit. At present the Vestry paid to the gas company £12,000 per annum for street lamps, and about £2,000 for the lighting of various public buildings. Even if they only saved that £14,000, they would save a large amount of interest, and provide a fair sinking fund. Mr. Charles thought there ought to be enquiry before even the cost of the provisional order was incurred. The motion, after further discussion, was adopted.

Lighting at Newport.—The electric lighting of the borough of Newport is now within measurable distance. The stage now reached is that, as mentioned elsewhere, of inviting tenders for the equipment of the station, which is to be provided on land belonging to the Corporation in New Dock street, and also for cables, culverts, arc lamps, and lamp standards, switches, fuses, meters, and all the appliances for furnishing an electrical supply. Eighty arc lamps are intended to be provided for street lighting, of which 50 will be put down as an instalment, and for the home 10,000 incandescent lamps will be arranged for. Newport is to be equipped with the high tension alternating current system. The town is a large district with a scattered population. The cost of the initial instalment will be covered by a loan of £28,000, and only the western side of the borough will be dealt with. Prof. Robinson was consulted as to the idea of burning house refuse beneath the boilers, but he worked out the profit and loss against the use of the said refuse. Newport possesses power which might be utilised in the rapid flow and the great fall of the Usk, besides the power which might be obtained from the "head" of water descending from the higher to the lower reservoirs on the slopes of Twym Barllwm. The history of the undertaking by the Corporation to provide electrical energy for the borough extends back to the year 1889, when no fewer than three companies sought to obtain powers to supply Newport with electricity. The Corporation successfully overbore all these sanguine promoters by declaring its intention to do the thing itself, and in 1890 gave the usual notices by which, in the year following, the Board of Trade granted the provisional order. As soon as the Corporation were armed with this authorisation the sub committee of the Parliamentary and Improvement Committee set to work. Besides St. Pancras, West Brompton, Chelsea, Leeds, Bradford, Oxford, Bournemouth, and Blackpool have been visited. Mr. Robert Hammond has been chosen as the consulting engineer to the Corporation.

Shiplighting.—In connection with the refitting of the "Howe," it is satisfactory to learn (writes a correspondent) that the only part of the work given by the Admiralty to outside contractors has recently been successfully completed by an Edinburgh firm. To Messrs. King, Brown, and Co., of Rosebank Electric Works, was entrusted the work of completely renewing the electric light and gun firing circuits, as, owing to the limited time available, the dockyard authorities were unable to take the work in hand themselves. The "Howe" is lighted by means of 520 16-candle incandescent lamps, in addition to the usual yardarm reflectors, masthead, side and semaphore signalling lamps, cables also being led to four search light projectors; while the gun firing arrangements comprise electric circuits, with the necessary batteries and firing keys for the four 63 ton barbette guns, for the six broadside guns, and for five torpedo tubes. Over 120 men were employed by the contractors, the work being carried on continuously day and night till its completion, which was effected within the brief space of 10 weeks from the date of order. The experiment of placing such a contract with a private firm has, in this case at least, proved so satisfactory that the authorities contemplate taking the same course in connection with several other vessels at present refitting in Chatham Dockyard. A twin-screw steamer of 9,000 tons, built for the Atlantic trade of the International Navigation Company, has been launched from the shipbuilding yard of Messrs. James and George Thomson, Limited, at Clydebank, near Glasgow. The vessel, which was named the "Kensington," will be lighted throughout by the electric light, for which a complete installation of engines and dynamos has been fitted by the builders. The Admiralty have approved a proposal to fit Messrs. Evershead and Richards's engine-room telegraph in the battleship "Howe" for trial. A steel screw steamer, which has been built to the order of Messrs. J. M. Lennard and Sons, Middlesbrough, for the purpose of carrying petroleum in bulk, has been launched from Sir Raylton Dixon and Co.'s Cleveland Dockyard, Middlesbrough. The vessel is provided with the electric light.

Preston.—The proceedings of the Streets and Buildings Committee, presented at a meeting of the Town Council last week, set forth that, pursuant to resolution of the 2nd of October, the surveyor had submitted a plan of his suggestions as to proposed lighting by electricity of the portion of Church street from Lancaster-road to the gaol, and that the committee resolved that the gas lamps in Church street from Lancaster-road to the gaol be provided with 10ft. burners, and that six additional gas lamps be put down, and that in the meantime the consideration of the plan for electric lighting be postponed. Alderman Satterthwaite, in moving the adoption of the proceedings, said it was understood a year ago when they lighted Fishergate with the electric light that it was to be an experiment as to whether they were to extend it at any future time. The committee had given the matter their consideration, and they did not, as this recommendation said, see their way to recommend the extending of the electric lighting to Church street. They found that to light Church street in the same manner as Fishergate was lighted at the present time would entail an additional expenditure for the present of £112. The committee did not consider that the amount of light in Fishergate was worth that additional expenditure of money per annum. They considered that for an expenditure of between £30 and £40 additional they could get light more generally diffused, and which would enable passengers, both by foot and vehicle, to be illuminated sufficiently, and with lights at more frequent intervals than by the electric light. They thought that that additional expenditure, £30 or £40, would serve the town better than by going to the expenditure of an additional £80 or so, hence their recommendation. This was seconded. Councillor Myres moved an amendment that the matter in question be referred back to the committee for reconsideration. He presented a petition from the residents in Church street protesting against the decision of the committee as to the better lighting of the streets. The memorialists understood that the borough surveyor had reported favourably upon the electric lighting. They very much preferred the electric light, and did not see why they should not have the same advantages in this direction as the residents in Fishergate, and they hoped the question would be reconsidered, as there could be no doubt that the electric light was a better illuminant for street purposes than gas. Councillor Humber seconded the amendment. After further discussion the amendment was rejected, and the proceedings of the committee were confirmed.

The Leeds Electric Tramway.—Writing to a Leeds paper on the 26th ult., Mr W. S. Graff Baker says: "I note in your issue of even date a letter on this subject over the signature of Mr. G. M. Roberts, following upon one signed 'Celerity,' in your issue of Monday. As Mr. Roberts says, there can be no doubt that correspondence on this subject from your readers in Leeds would be most valuable in enabling the opinion of the residents of Leeds, with reference to same, to be most correctly arrived at. Having had a long experience in electric traction, and being well

acquainted with all systems in vogue, but yet being in a position where I am not tied to the use of any particular system (as is the case with most electrical companies), I can offer what might be called a composite system of electric traction, which in my opinion would be most suitable for the local conditions obtaining in Leeds. It is on the centre bracket suspension system I would suggest that when the Corporation are relaying the existing double line, the space between the inside rails (when the width of the streets permit) should be increased to 4ft., which is the standard in many towns, notably in Glasgow and Edinburgh. By doing so facilities are afforded for the erection of the centre bracket system as shown, the poles being ornamental in character and placed in the centre of refuges, with low ornamental posts at either end, and capable of safely and comfortably accommodating two persons. These standards and refuges can be placed at least 120ft. apart, and every alternate pole could be fitted to carry electric lights either arc or incandescent for street-lighting purposes, thus securing the ideal position for street lamps, viz., in the centre of the roadway. This, as Mr. Roberts states, is adopted by the St. Pancras Vestry, in the Euston and Tottenham Court roads London. By the adoption of such central system of lighting, the sidewalks are cleared of lampposts, with the effect of helping the appearance of the streets materially, while the standards in the centre become very unobtrusive. The only wires carried overhead would be the trolley wires, all others (including the electric light wires) being laid underground and led up through the centre of the standards to the trolley wires or to the lamps. This system has the great advantage, thanks to the 'refuges,' of assisting most materially in regulating the traffic of the streets, and in maintaining the 'rule of the road.' In streets where double lines do not exist, or where the streets are too narrow to enable the necessary width to be secured between the inner rails to allow 'refuges' and standards as suggested to be erected, I would suggest the trolley wire being carried upon cross-wires attached to ornamental brackets on the fronts of the houses on either side of the street, thus doing away with poles entirely; and in the heart of the city, where the local conditions permit, a conduit system, carrying all wires under ground. This latter system is to be avoided, however, where possible, owing to the fact that no conduit system that would be permitted in England is a commercial success at the present moment, and until the difficulty to be experienced in keeping the conduit free from surface water during heavy rains be overcome, such a conduit system cannot be depended upon for a uniformly regular service, as in the event of the drainage not being perfect, and the conduit filling with water, it would be impossible to operate the cars. In Boar lane, however, I am of opinion that the conduit could be laid to advantage, as the facilities for drainage towards the river are sufficient to enable it to be always kept free from water. The same cars would use either the overhead system or the conduit (where laid) indifferently, and I feel sure that by the exercise of a wise discretion in the combination of the systems suggested, an effect would be obtained that should satisfy most critics. May I point out that the system of double pole cross suspension, as erected in Roundhay-road, was done at the request of the Corporation, a special clause being inserted in my agreement with them demanding the erection of such system. I shall be glad if your readers will care to criticise these suggestions in the columns of your paper."

PROVISIONAL PATENTS, 1893.

OCTOBER 23.

19884. **Improvements in electric indicators or annunciators.** Max Binswanger, 73, St. Stephen's road, Upton Park, London.

19921. **Improvements in time apparatus for automatically switching gas and electric lights.** Herbert Young Dickinson, 36, Gray's inn road, London.

19934. **Improved electricity meter for continuous and alternating currents.** Charles Denton Abel, 28, Southampton-buildings, Chancery-lane, London. (Compagnie Anonyme Continentale pour la fabrication des compteurs à gaz et autres appareils, France.)

19967. **Improvements in secondary electric batteries.** Wilhelm Petschel, 99, Chausseestr, Berlin. (Complete specification.)

OCTOBER 24.

9989. **Improvements in the mode of and means for operating electric bells.** John Joseph Husselbee, 2, Hunter's-vale, Birmingham.

20011. **Improvements in electric lampholders and switches.** Gustav Binswanger, 73, St. Stephen's road, Upton Park, London.

20023. **Improvements in the method of heating, welding or working metals electrically, and in apparatus therefor.** William Phillips Thompson, 6, Lord street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

20046. **Electric selecting devices.** Samuel S. Bogart and Electric Selector and Signal Company, 17, Basinghall street, London. (Complete specification.)

20047. **Improvements in electrical apparatus for controlling semaphore and other signals.** Michael B. Leonard and Electric Selector and Signal Company, 17, Basinghall-street, London. (Complete specification.)

20069. **Improvements in apparatus for controlling the application or use of electric currents of high tension and great quantity.** Robert Lundell and Edward Hibberd Johnson, 45, Southampton buildings, Chancery-lane, London. (Complete specification.)

OCTOBER 25.

20114. **Improvements in galvano plastic processes for the production of decorative objects or articles.** Ernest de Pass, 73, Fleet street, London. (Jules Ranvier, France.)

20116. **Improvements in electrolytic cells.** Ludwig Mond and Robert Ludwig Mond, 6, Lord street, Liverpool.

OCTOBER 26.

20155. **Improvements in or relating to electric bell ringing.** George Grey Turner, 3, St. Nicholas buildings, Newcastle on Tyne.

20191. **Improvements in electric stop motion drawing frames for fibrous materials.** Edward Tweedale, Samuel Tweedale, and Joseph Smalley, Globe Works, Castleton, near Manchester.

20226. **An improved electric clock.** Gaston Hervieu, 9, Warwick-court, Gray's inn, London.

20229. **Improvements in electric arc lamps.** Alfred Julius Boult, 323, High Holborn, London. (La Societe Madhabeau and Fritsch, France.)

20231. **Improvements in electric clocks and electric meters.** Frank Panter and George Hill, 6, Bank street, Manchester.

OCTOBER 27.

20325. **Improvements in the manufacture of electric pushes, pulls, and switches.** William Robert Webb, 4, South-street, Finsbury, London.

OCTOBER 28.

20381. **Improvements in joints for electric light fittings.** Ernest Alexander Claremont, 53, Arcade chambers, St. Mary's gate, Manchester.

20384. **Improvements in electricity meters.** George Hookham, 7, New Bartholomew street, Birmingham.

20402. **Electrical station indicator for use in railway carriages or other public vehicles.** Herbert de Grave, 1, Amberley road, West hill, Sydenham, London.

20408. **An improvement in or applicable to ear-pieces for telephone receivers.** James Watkin Kinnibrugh, 191, Fleet street, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1892.

17826. **Transforming alternating into continuous electric currents.** Hutin and Leblanc.

19543. **Electric telegraphic apparatus.** Stevens.

22035. **Electrical switches, etc.** Binswanger.

22129. **Electric switches.** Wharton.

22858. **Electric arc lamp.** Davenport.

23674. **Distributing electricity.** Harrison.

24071. **Evaporating solutions by application of an electric current.** Schiff.

1893.

2318. **Electric percussive tool.** Williams.

13774. **Maintaining the human body in electrical connection with the earth.** Spratt.

14756. **Dynamo-electric generators and motors.** Brooker. (Ryan.)

15479. **Electric arc lamps.** Howard.

15669. **Electrolytic treatment of liquids.** Browne. (Vogelsang.)

16019. **Metal posts for electric wires, etc.** André.

16074. **Lighting gas by electricity.** Geyer and Stegmeier.

16136. **Battery electrodes.** Boult. (Hensel.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13
Electric Construction	—	1⅞
House-to-House	5	2½
India Rubber, Gutta Percha & Telegraph Co	10	22½
Liverpool Electric Supply	5	6¼
	3	4⅛
London Electric Supply	5	1
Metropolitan Electric Supply	—	7
National Telephone	5	4⅞
St. James', Pref.	—	8¾
Swan United	3¾	3¼
Westminster Electric	—	5¼

NOTES.

Glow Lamps.—Lamps are now cheap; the master patent expires to-day. Who'll buy?

Leeds. A difficulty has arisen as to the terms upon which the Corporation is to take over the tramways.

Zurich.—An electric tramway now in course of construction is expected to be completed by the end of the year.

Collision.—A collision the other day between a trap and an electric car in Leeds resulted in the overturning of the trap and injury to one of the occupants.

Brighton.—It appears that the electrical engineer to the Corporation of Brighton still has a vacancy for an articled pupil at the borough electricity works.

High-Speed Engines.—It is announced that the Compagnie de Fives-Lille have devised a new type of high-speed engine intended for the driving of dynamos.

Won in a Canter.—The Shaftesbury Debating Society at Swansea have debated the relative merits, as illuminants, of gas and electricity. Electricity won in a canter.

Post Office.—The Postmaster-General gave on Saturday, at the Mansion House, some interesting information concerning the postal and telegraphic departments.

Personal.—Mr. Francis Teague has been appointed resident manager of the Coatbridge new generating station of the Scottish House-to-House Electricity Company.

The Show.—"Yes," remarked one City man in the train yesterday, "we'll be busy in the City to-day. "Of course," replied another; "but wait till the show is run by electricity."

Inverted Arc Lamp.—The inverted arc lamp which was described in our issue of the 27th ult., was shown in action at the recent meeting of the Institution of Mechanical Engineers.

Munich.—It is submitted, when the central station now being established in Munich is completed, that that city will take the first place among electrically-lighted towns on the Continent.

Fort Beira.—Mr R. G. Webster, M.P., has obtained a concession from the Mozambique Company for the construction of piers and landing-stages, telegraphs and telephones, at Fort Beira.

The Laying of Mains in France.—The Minister of Public Works has just published regulations determining the conditions under which electric light and power cables may be laid under public thoroughfares.

Train-Lighting.—It is pointed out, with reference to our note last week on the extension of the electric lighting of trains on the London, Brighton, and South Coast Railway, that the company are also increasing the number of gas-lighted trains.

Kensington.—The report on the electric lighting of Kensington, prepared by Major-General Webber and Mr. Philip Monson, and referred to in our last issue, considers the question of combining the use of a refuse destructor with steam plant.

Caustic Soda.—The new electro-chemical process, invented by Mr. Castner, for the manufacture of caustic oda and chlorine direct from common salt by electrolysis, regarded by the chairman of the Aluminium Company as romising good results.

Camberwell.—In the course of an interview, Mr.). C. Preston, the leader of the Moderate party in the Jamberwell Vestry, said that until the electric light can be produced at the same cost as gas, there is not much chance of getting it adopted in Camberwell.

Institution of Civil Engineers.—The sittings of the institution will be resumed on Tuesday next, the 14th inst., at 8 p.m., when Mr. Giles, the president, will deliver an inaugural address. He will also present the medals and premiums awarded at the close of the last session.

Pocket Diary and Year-Book.—The "Mechanical World Pocket-book and Year-book" for 1894 has just been issued by Messrs. Emmott and Co., Limited, of New Bridge-street, Manchester, and 85, Strand, W.C. It is an excellent publication for engineers, draughtsmen, mechanics, and others, and is cheap at 6d.

Lord Mayor's Coach.—The carriage-builders who were commissioned by the Lord Mayor to build him a state coach, have just completed a very handsome equipage. The electric light has been introduced in the coach on the same principle adopted for the state coach made for Sir David Evans on his accession to the civic chair.

Junior Engineering Society.—The inaugural meeting of the thirteenth session will take place this (Friday) evening at the Westminster Palace Hotel, S.W. The chair will be occupied by the retiring president, Dr. John Hopkinson, F.R.S., and Mr. John Wolfe Barry, M.Inst.C.E., will deliver his presidential address.

Lubricators.—A copy of their trade price-list of grease and oil lubricators issued by Messrs. O. Berend and Co., of 61, Fore-street, E.C., has been forwarded to us. In addition to containing illustrations and prices of various kinds of oil and grease lubricators, particulars are given of oil-cans, grease-filters, grease and oil syringes, oil-filters, etc. The list will prove of value to the trade.

Fusing of Wires.—An investigation made into the circumstances attending the outbreak of fire in the gunners' storeroom of the second-class battleship "Thunderer" has shown, it appears, that the fire originated with the fusing of the electric wires, which are said to have set fire to the wooden casing and extended to the stores in the compartment. The damage to the ship was comparatively slight.

Large Wimshurst Machine.—A large machine has just been completed for Lord Armstrong by a Fleet-street firm. It has 16 plates, each 34in. in diameter, and gives a spark in air 16½in. long; the glass case in which it is contained, all but the terminals and their supporting tubes, measures 7ft. by 6ft. by 3ft. The thick glass tubular supports of the terminals are made to serve also as condensers.

Proposed Coast Electric Railway.—In a Bill to be promoted next session, the Taff Vale Company may seek permission to construct an electric railway along the foreshore. This would bring Penarth into very much closer connection with the Bute Docks, the existing means of communication along the lower Penarth road being by means of a ferry-boat and waggonette, the latter not being always available.

Lightship Communication.—The United States Lighthouse Board has been successful in forming electrical communication at a distance of more than a mile from shore. The difficulties which have hitherto prevented connecting with the land by electric cable a vessel swinging at anchor at sea are said to have been overcome by attaching the core of the cable to the anchor chain, and making a conductor of the latter.

Society of Arts.—At meetings of the Society of Arts after Christmas, papers will be read by Prof. H. Robinson,

M.Inst.C.E., on "The St. Pancras Electric Light Installation," and by Mr. W. H. Preece, F.R.S., on "Electric Signalling Without Wires." At the first ordinary meeting on Wednesday next, the opening address of the session will be delivered by Sir Richard E. Webster, Q.C., M.P., Chairman of the Council.

The Police and Telephony.—The Hertfordshire constabulary have just brought into requisition telephonic communication between Hitchin, Baldock, and Royston—three of their principal stations. All the police stations in the county are, by order of the County Council, to be brought into direct communication with each other. The wires are fixed to the various telegraph posts, thus curtailing the expense to the local authorities.

Lightning Express Railway Service.—We are informed by Mr. Behr, whose proposed lightning express railway service was referred to in previous issues, that he has arranged with the Thames Ironworks and Shipbuilding Company for experiments to be made on a large scale to perfect the system with special reference to the electrical details. Whilst giving publicity to this item, we must say that we neither think Mr. Behr's system practicable nor desirable.

An Iron Automaton.—Iron soldiers are now suggested, if we are to believe a statement made in a Spanish paper. The inventor claims to have produced an iron automaton, whose inner organs are machinery, and whose diet is cartridges, renewable at will. The rifle which the monster carries can be turned in any direction, and delivers 50,000 shots in 15 minutes! The machinery is set in motion by electricity, but nothing will set the figure itself in motion. Next, please.

Royal Meteorological Society.—The meetings of the society, held at 25, Great George-street, Westminster, will for the future commence at 8 p.m. At the ordinary meeting on Wednesday, the 15th inst., papers on the following subjects will be read: "The Great Drought of 1893 and its Attendant Meteorological Phenomena," by Fredk. J. Brodie, F.R.Met.S., and on "Thunder and Hail Storms over England and the South of Scotland, July 8th, 1893," by William Marriott, F.R.Met.S.

Foreign Patents in Russia.—M. Moskaleff recently submitted to the administrative council of the Russian Imperial Technical Society a scheme for the suppression of all patent rights in Russia for foreign inventions. The proposal gave rise to great controversy among the members of the society, and in a certain section aroused considerable indignation. The society will consequently have to decide by vote whether or not the scheme shall be submitted to the approval of the Council of the Empire.

Railway Rates.—The London Chamber of Commerce is constantly being asked by members for advice in regard to paying their accounts with the railway companies on the basis of 5 per cent. increase. They have always been advised to pay "on account" only (and not including the 5 per cent.) pending the issue of the report of the Select Committee on Railway Rates which sat during last session. This report may be expected this month, and until its tenor is made known the course above referred to is the best that can be recommended by the Chamber.

The Annual Dinner.—Amongst the invited guests who have accepted the invitation of the President and Council of the Institution of Electrical Engineers are the President of the Board of Trade; the Postmaster-General; Sir Thomas Biomefield, Bart.; the presidents of the Institutions of Civil Engineers, Mechanical Engineers, *Iron and Steel Institute*, the Chemical Society, and of the *Physical Society*; the Astronomer Royal; the Hydrographer to the Admiralty; Sir James Crichton Browne; Sir Frederick Bramwell, Bart.; and Sir Robert Rawlinson, K.C.B.

Communication with Lightships.—Two vessels are being prepared, under the direction of the Trinity House, to relieve the lightships at the North Goodwin Sands and the Kentish Knock. Both vessels will be in direct electrical communication with the shore, the cable from the North Sands having its land connection at Dumpton Gap, and that from the Kentish Knock at Kingsgate Bay. The Post Office authorities will lay the cables, and the cost of the work and maintenance charges will be defrayed out of money specially voted for the purpose by Parliament.

The "Medical Battery" Company.—It is now well known that Mr. C. B. Harness has had a writ for libel served upon the *Pall Mall Gazette*, and that the proprietor of the latter has instructed his solicitors to see that no delay takes place in bringing the case into court. Apart from this a receiver has been appointed on behalf of the debenture-holders, and a petition for compulsory winding up the company has been presented, and allowed to stand over for a week. Moreover, Mr. Harness was on Tuesday arrested, in conjunction with others, on four charges of fraud, and has been remanded for a week.

Retrogression in Paris.—It appears that the electric supply companies in Paris have discovered for some time past that the consumption of current has notably decreased, and particularly during the first seven months of this year, as compared with the corresponding period of 1892. It is generally attributed that the falling off is due to the extraordinary development of the Auer intensity gas lighting system which has been substituted in various establishments for incandescent lamps. It is not thought that the success of the Auer system will last for long, as consumers will not fail to ascertain that the economy obtained with this system is more fictitious than real.

The Royal Society.—At the anniversary meeting of this society on the 30th inst., the following will be submitted for election to form the new council for the ensuing year: President, Lord Kelvin; treasurer, Sir John Evans; secretaries, Prof. M. Foster and Lord Rayleigh; foreign secretary, Sir Joseph Lister; other members, Prof. J. B. Balfour, Mr. A. A. Common, Mr. A. R. Forsyth, Mr. Glazebrook, Prof. A. H. Green, Sir John Kirk, Prof. Oliver Lodge, Sir John Lubbock, Mr. W. D. Niven, Dr. Perkin, the Marquis of Salisbury, Prof. Burdon Sanderson, Mr. A. Sedgwick, Prof. T. E. Thorpe, Prof. W. A. Tilden, and Prof. Unwin.

The New Decimal Association.—The third report of the executive committee of this association states that on the whole good progress has been made since the issue of their last report. In May a memorial was forwarded to the President of the Board of Trade pointing out that the weights and measures should be changed before the coinage, and praying him to support the appointment of a select committee to consider the question. No official reply has been received, but it is understood that the President of the Board of Trade is disposed to give his assistance, and that at the first favourable opportunity an announcement will be made.

The Devil's Dyke.—A scheme has been advanced for increasing the attractions of the Devil's Dyke, at Brighton. The project proposes (1) to run a cable-car from a spot near Dyke Station to the ravine from which the place derives its name, and (2) to run an aerial flight about 1,250ft. across the Dyke by means of a car suspended on a cable, and the novelty of which will be that the weight of the car will, to a certain extent, be relieved by a cigar-shaped balloon,

which will be made to rise by the aid of powerful fans worked by electricity. A third portion of the scheme is a steep gradient tramway down to the Devil's Punch Bowl, which will be laid out as tea gardens.

Goldsmiths' Industrial Institute. — The Goldsmiths' Company's Technical and Recreative Institute, at New Cross, has now on its books the names of upwards of 4,000 members. The area over which it extends its influence comprises Greenwich, Deptford, Woolwich, Peckham, Camberwell, and South-East London, and so popular have the various classes become, especially those of art, engineering, chemistry, and plumbing, that this year there have been 11,000 entries, as against 9,000 last year. A technical lecture was, a few days ago, given to the students of the Engineering Society by Mr. J. Macfarlane upon "Nothing; or the Non-existent in its Physical Aspects and as Related to Engineering."

Electrolytic Action on Cables.—The action of electric currents extends to water and gas pipes and to almost all other buried metals, according to a report just issued by the Bell Telephone Company, of Boston. The report states that the overhead single-trolley system of electric railways seems to be the cause of most of the corrosion, and that the heavy currents appear to follow the cable sheaths of telephone cables as conductors. It is said that the lead of the cable sheaths is corroded wherever the current leaves the cable and passes into moist earth or the moist air of the ducts or manholes. The destruction has occurred in some places where the potential was less than half a volt. The injury to water and gas pipes is stated to be as serious as that done to telephone cables.

Influence of Electricity on the Carburation of Iron by Cementation.—A paper on this subject is given by M. J. Garnier in *Compt. Rend.* A bar of steel, containing only 0·1 per cent. of carbon, and a rod of gas carbon, were placed end to end in a refractory tube and well insulated. The tube was then heated at 900deg. to 1,000deg., and a current of 55 amperes and seven volts was passed from the carbon to the steel. After three hours it was found that that part of the iron opposed to the carbon cut glass easily, and a section showed that cementation had taken place to a depth of about 10mm., whilst the carbon was corroded at the surface of contact. Two bars of steel were then packed side by side in wood charcoal with a space of 10mm. between them, and were heated at 900deg. to 1,000deg. for three hours, a current of 55 amperes and 2·5 volts being passed from one to the other. It was found that the bar which served as the anode was practically unaffected, whilst in that which played the part of the cathode cementation had occurred to a considerable depth. It would seem, therefore, that at about 1,000deg. the cementation of iron takes place with very great rapidity under the influence of a comparatively weak electric current.

Electrical Progress in America.—Says a correspondent of one of the daily newspapers: "I went over the Carnegie Works at Homestead a few days ago, and found that the work of handling the bars of white-hot metal as they are drawn from the furnaces, which is done in the great English steelworks by hand, is all done at Homestead by electric machines, which glide back and forth on rails, fetching the long bar out from the furnace, and then drawing it in again by the most ingenious methods. As regards electric lighting, while no city here that I know is so brilliantly illuminated as the City of London by night, yet electric lighting is far more general. Not only in the great cities, miles of roads of the prettiest villas in the world out of Boston being lighted by electricity, but a tiny little co-operative town which I visited a few weeks ago in Southern Illinois, containing less than 150 people, had its two little avenues lighted by incandescent globes. The development of electricity is as much a feature of the marvellous growth of America as is the enormous increase in population. It is a development which is greatly complicating social problems, and which is undoubtedly heading in the direction of municipal collectivism."

E.M.F. in Electrolytic Analysis.—Mr. H. Freudenberg, in the *Zeit. Physikal Chem.*, deals with this subject: It has been shown that different values of the E.M.F. are necessary to electrolytically decompose aqueous solutions of different salts. In some cases the electrolytic separation of two metals from a mixed solution of their salts may be effected by choosing an E.M.F. just sufficient to decompose one salt, but insufficient to decompose the other. The author has made a large number of experiments on this subject, and has succeeded in effecting the separation, in acid solution, of various metals which show normal decomposition values of the E.M.F. Thus, silver may be separated from arsenic and bismuth; mercury from copper, bismuth, and arsenic; and, finally, copper and bismuth from cadmium and arsenic. Solutions with abnormal decomposition values were also investigated, without practical result in the case of the oxalates, phosphates, and ammonium double salts. Cyanides and sulpho-salts, however, often give methods of separation. For example, silver may be separated from antimony, and mercury from copper and cadmium in potassium cyanide solution, and mercury may be separated from antimony and arsenic in ammoniacal solution.

Soldering the Electrodes of Accumulators.—In the *Foreign Abstracts* of the Institution of Civil Engineers, an improved method of soldering the electrodes of storage cells is described by Messrs. K. Strecker and Th. Karrass. In view of the increasing use of storage batteries for telegraphic purposes, the authors found it desirable to devise means of joining up the lead plates more perfectly than by the soldering iron, which frequently effects merely a superficial union; and more easily than with the gas blow-pipe, which is not very portable and requires practice to use it. They have worked out the following method: The strips of lead for making the joints are immersed for some time in strong potash solution, and then well washed with water to clean the surface. Immediately before the operation the ends of the electrodes and the lead strips are carefully scraped bright; they are then held in position in a mould somewhat in the form of a pair of tongs, which completely encloses the proposed junction beneath and at the sides. Melted lead is then poured in from a ladle till the mould is full. After a little practice it is easy to get the right temperature to ensure the superficial melting of the two surfaces by the hot metal, so as to make a perfect joint.

Electric Cooking and Heating Appliances.—From a copy of the first edition of the catalogue dealing with electric cooking and heating apparatus issued by the General Electric Company, Limited, of 69 and 71, Queen Victoria-street, E.C., it appears that a very wide range of these appliances is now available. Of course, with apparatus of this character, one of the most important points which have weight in hotels, restaurants, clubs, mansions, etc., is that of cost. In this connection, the company state that the cost of the current consumed for cooking and heating by means of the appliances described in the catalogue is not great. For instance, a pint of water, with a kettle of 100 volts and three amperes, and with current at heating rates of 3d. or 4d. per unit, can be boiled in 12 minutes at a cost of approximately one farthing. The catalogue gives illustrations and particulars of electric cooking kettles,

coffee-machines; frying, stew, and sauce pans, electric steam cookers, fish-kettles, electric ovens, electric grillers, hot-plates, electric heating irons for domestic and tailors' purposes, electric warming stoves, etc. Among other novelties dealt with are cigar lighters, electric shaving and glue pots, electric curling-iron heaters, portable lamps, electric fan sets, etc. We are informed that the company have been very successful in the production of the electric cooking and heating appliances.

Electrolysis of Steam.—This subject is treated by Mr. J. J. Thomson in the *Proceedings* of the Royal Society. A current of steam was passed through the middle limb of a T-tube, the closed side limbs of which were furnished with delivery tubes, and also with gold or platinum electrodes, between which sparks might be passed through the steam. The delivery tubes conducted the gases into two eudiometers, in which the gaseous mixture formed on passage of the sparks was exploded. When the sparks were from 1·5mm. to 4mm. long it was observed that within the limit of error of the experiment the volumes of the excess of hydrogen in the one tube and of oxygen in the other, which remain after the explosion of the mixed gases, are respectively equal to the volumes of the hydrogen and oxygen liberated in a water voltameter placed in series with the steam-tube; and that the excess of hydrogen appears in the tube which is in connection with the positive electrode, the excess of oxygen in the tube which is in connection with the negative electrode. When the spark length is greater than 4mm., the first of the preceding results ceases to hold, and when the spark length is increased to over 11mm., the excess of hydrogen, instead of appearing at the positive electrode, changes over to the negative, the excess of oxygen at the same time going over from the negative to the positive electrode. When the sparks are very much longer, about 22mm., reversal again takes place, the hydrogen appearing at the positive electrode. The author finds that when the arc discharge passes through hydrogen and oxygen respectively, the hydrogen behaves as if it had a negative charge, and the oxygen as if it had a positive one.

Automatic Starter and Time Recorder.—An automatic starter and time recorder for use in connection with horse racing, pedestrianism, and bicycling has been devised by Mr. Alfred Bartlett, who hails from New Zealand, and who now has one of the machines on view at the office of the Rosehill Racing Club. The mechanism is enclosed in a cylindrical case, on the top of which is fixed a horizontal dial, which is divided into 60 seconds, and each second is subdivided into fifths, while a smaller dial registers the minutes. An outer circle has a number of stops, numbered from 1 to 60, and is brought into use in starting for events in which the time system of handicapping is required. In connection with the "clocking" machine is an electric battery with bell attachments, which is fixed at the starting point, while the time recorder is placed at the winning-post. The mechanism for starting time-handicapped events is brought into operation by pressing down the buttons on the outer rim of the dial, in accordance with the time adjustments fixed for the starters, and, starting from zero, the times at which the other horses handicapped in the race leave the mark are accentuated by a bell, so that no mistake can occur in despatching the field just as the handicapper had arranged. The seconds hand, which registers the time on the large dial, is carried on a cylinder about 3in. in diameter and of a similar depth. The outer surface of the cylinder is vertically divided into 12 parts, corresponding with which, on the inner surface of the cavity in which it revolves, are a dozen inked points. The circumference of the cylinder is divided into seconds and fifths, and the aforementioned inked points are electrically connected with the tapes at the winning end of the running tracks. The signal for starting is given by a loud-sounding electric bell at the starting-post, and simultaneously the recording machine at the other end is brought into operation. The tapes at the winning end of the tracks are electrically connected with the inked points, and the instant that the connection is broken the inked point registers on the corresponding section of the revolving cylinder the time occupied in covering the ground, as well as the relative positions of each competitor as he breasts the tape.

City Lighting and Telephony.—The members of the City Commissioners of Sewers were much concerned on Tuesday on the subject of electric lighting. Alarmed by a statement that there were serious defects in the "electrical arrangements" of a City firm, the Commissioners unanimously decided to refer to the Streets Committee the question of appointing inspectors under the Electric Lighting Acts. It was also resolved to refer to the same committee the subject of lighting Crutched-friars by electricity. Mr. C. T. Harris, who moved this resolution, mentioned that the cost of lighting the eastern district was nearly 20 per cent. in advance of that for the main thoroughfares of the City. In the eastern district there were 233 arc lights, which at £26 per annum, cost £6,058; adding to that the cost of maintaining disused gas lamps, about £450, the total would be £6,500. The previous cost of lighting by gas the whole (three districts) of the City with 1,730 lamps was £5,550. To light the district by electricity thus cost £1,000 in excess of the expenditure required to light the whole of the City by gas. At the same meeting the engineer submitted a report on the failures during the past six months in connection with the electric light. The total number of arc lamps in use was, he reported, 475. The number of gas lamps disused, but maintained ready for lighting, was 1,219. The total number of failures of the electric light during the period in question was 301. The most serious failure was on May 7, when 42 lamps were not lighted until 9 o'clock. The explanation given by the company was that the switch was defective. On June 17, 65 lamps went out for a considerable period, but the gas was not lighted. The explanation given by the company was that there was negligence on the part of the stoker at Wool-quay. On July 27, 96 lamps went out, and the reason given was the breaking of a belt. The 475 arc lamps at a cost of £26 per annum each gave a sum of £12,350. The length of streets lighted was 13 miles. The fines for these defects would be deducted from the next account of the company. The information regarding these failures was received from the police force, and the returns were sent to the company's office, and filed in his office. This report is now being printed and circulated. With regard to the telephone tubes of the City of London Electric Light Company, the Commissioners were gratified—for the present, of course—to learn from the company that except for purposes of their own the tubes were not being used for telephonic purposes. As a wind up on matters electrical, the Commissioners instructed the Streets Committee to work in accord with the Association of Municipal Corporations on the subject of the agreement to be signed between the Government and the National Telephone Company.

Electricity in Coal Mining.—A paper on "Collieries and Colliery Engineering," referred to in our last issue, was read on Monday evening before the Society of Engineers by Mr. R. Nelson Boyd. In the course of the paper the author said that the gradual development of the coal

trade had brought with it the necessity for improved means of transport, both above and below ground. Every kind of conveyance has been from time to time applied in coal-mining, from the backs of women, in Scotland, up to the electric locomotive as now introduced in some mines in Germany. The question of undercutting the coal by machinery had been very much considered. One of the most recent was the electric coal-cutting machine brought out in 1887 by Messrs. Bower, Blackburn, and Mori. This consists of a frame travelling on wheels carrying a specially-designed electric motor driving a shaft which carries the cutter attached by bolts to a coupling. This cutter consists of a bar carrying a series of star-shaped cutters specially formed. The whole motor and the shaft carrying the cutter-bar can be rotated in a horizontal plane for the purpose of bringing the cutter in and out of the coal. The cutter is revolved by an electric motor at the rate of about 600 revolutions per minute, and the motor develops a power of six to nine actual horse-power, according to the hardness of the seam. When cutting is commenced the motor is started, and the turntable rotated by a worm wheel till the cutter has swept through a right angle, and is 3ft. 6in. deep in the coal. It is then drawn along the face by a winch under or overcutting the coal to that depth. The actual work effected by this cutter has been 45 yards in an hour, including all stoppages. The power is transmitted from dynamos on the surface by means of two cables. The author said that the electric coal-cutter had not had time to become established as a success, and in general use certainly no coal-cutting machine had as yet proved universally applicable, although there were some machines in daily use in different districts. It would seem that the different peculiarities of various coal-beds as to thickness, hardness, inclinations, and so on, almost required a different kind of machine for each bed. With regard to the transmission of power by steam, ropes, compressed air, electricity, petroleum or gas engines, and by other means, the results obtained by these diverse systems had not yet been sufficiently definite to enable a decided preference to be given to any of them. But it seemed as if for this purpose electricity would gain the day. At any rate, so far, the results had been favourable. Steam and compressed air had been in use for some time, but they were expensive on account of the loss in transit. Ropes gave very good results, but absorbed much power through friction if they had to be carried round and over many bends. Petroleum and gas engines remained to be tried, but an obvious objection to their introduction in a fiery pit was their danger. Electricity had been objected to on the same grounds, but with careful arrangements the transmission was practically safe. As an example of the progress that electricity has already made, as applied to the transmission of power underground, he gave a description of the electric plant in use at one of the Earl of Durham's collieries, and which is, perhaps, the largest applied to mining. The author concluded that electricity has to overcome a certain amount of prejudice and a good deal of apprehension as to danger on the part of colliery engineers, but it appeared to be making headway as a transmitter of power. For illuminating purposes underground, it had so far not proved a great success, and a practical miner's electrical lamp yet remained to be invented.

Checking Electric Supply.—In a recent issue of *L'Industrie Electrique* a description is given of the Martin check apparatus for electric supply. The following *résumé* of this article is given in the *Foreign Abstracts* of the Institution of Civil Engineers: "It is very usual in France for an electric lighting company to furnish current by contract to consumers, and in such cases a consumer may have any number of lamps installed so long as he never has more than a certain fixed number lighted at once. It is therefore necessary to use some apparatus for the purpose of preventing fraud and making it impossible to use more than the stipulated number of lamps at one time. As a rule, this object is accomplished by using switches with two or more different contacts, so that when the current is shut off from one circuit it is admitted to others. This method, however, complicates the internal wiring, and the grouping of the lamps easily permits of fraud. On the other hand, the reliability of cut-outs is very doubtful. The Martin apparatus is designed to prevent the use of more than the stipulated number of lamps, while permitting absolute freedom in the grouping or wiring of such lamps. Such an apparatus is also of use in a private installation, to prevent overloading of the generating plant. The apparatus is placed in one of the main leads, and consists of two mercury-cups provided with a metal contact-maker attached to the end of a lever, and provided with a spring to cause a quick break in the mercury cups. The lever is commanded by one or other of six pins standing at right angles to the flat face of a wheel, which is stationary when the stipulated current is not exceeded, and holds the contact in the mercury-cups. Clockwork is so arranged as to always tend to rotate the pin-wheel, and if this motion were not controlled, the circuit would be made and broken at short intervals by the contact-piece in the mercury-cups. One of the train of wheels is, however, provided with a single pin, which is held by a projection on a spring lever during the whole time that the current in the circuit does not exceed the quantity stipulated. The spring lever carries at its free end the armature of an electromagnet, which is placed in the main circuit, and the strength of the spring upon the lever is so adjusted that, so soon as the maximum stipulated current is exceeded, the armature is attracted and the train of wheels set free. Contact is then made and broken at short intervals of time, and the customer is obliged to take one or more lamps off the circuit, thus bringing the current down to the normal when the train of wheels is stopped and the permanent contact is again made. In actual practice a clock movement of the Japy type is employed, but only the five wheels of the striking mechanism are preserved, with the detent spindle and its lever, and the spindle of the hammer. The hammer shaft is retained, but the head is replaced by a piece of hard rubber, carrying a copper fork dipping into the two mercury-cups. The author gives some further details of the method of manufacturing this particular type of clock. He states that the act of switching in a 5-c.p lamp on a circuit of 110 volts is sufficient to actuate the apparatus—supposing, of course, that such a lamp be in excess of the stipulated number of lamps which are already lighted. The loss of pressure upon the circuit is said never to exceed 0·2 volt. The whole is covered with a glazed lid, and can be sealed up. A counterpoise is so arranged that it is impossible for a consumer to keep too many lamps lighted until the clock has run down, in which case the circuit would become permanently closed; the counterweight causes the circuit to remain permanently open until the number of lamps in use is reduced to the stipulated maximum. This instrument has, it is stated, given satisfaction in one of the eastern towns, and a servant of the company calls once a month upon each customer for the purpose of winding up the apparatus. Such a clock-movement would run for 15 days, and give 2,700 interruptions, and it is found that the spring is very seldom run down in a month."

REGINALD BELFIELD.

Electrical engineers are cosmopolitan, and, as is well known, many enterprising men have gained their experience from both sides of the Atlantic. The subject of this sketch is one of these. Born in Barbados in 1863, he received his education first at Harrison College in the island, and afterwards at Cheltenham College in England. It was during his life at Cheltenham that he first became interested in the study of electricity, and after leaving Cheltenham, Mr. Belfield entered the late School of Electrical Engineering, where he became a pupil of Mr. Desmond FitzGerald, whom he afterwards assisted in experimental work in secondary batteries and incandescent lamps. Subsequently Mr. Belfield joined the firm of Ferranti, Thompson, and Ince, afterwards going to the National Company for the Distribution of Electricity (better known as Gaulard and Gibbs), and for this company went out to America to introduce the secondary generator system in the States. In 1885 Mr. Belfield joined the Westinghouse Electric Company, then in process of formation, and the year following went with Mr. Stanley, the electrician of the company, to his laboratory in Great Barrington, Massachusetts, and assisted him in his experiments with the transformer and dynamo which were afterwards manufactured in such large numbers by the Westinghouse Company at Pittsburgh. After about a year at the laboratory Mr. Belfield returned to the works laboratory at Pittsburgh, and assisted in the development of the alternate-current system adopted by the company. In 1888 he came over to England in the interests of the Westinghouse Company, and on the formation of the Westinghouse Company of London was made chief electrician, which position has been held to the present day. Mr. Belfield is a member of the Institution, an associate member of the Institution of Civil Engineers, and a member of the Society of Arts. This rapid review of the experience of a young man will show that energy, knowledge, and adaptability to circumstances still play an important part in bringing about success.

ELECTRIC SUPPLY COMPANIES. I.

(Continued from page 415.)

WESTMINSTER ELECTRIC SUPPLY.—GENERATION AND DISTRIBUTION.

The arrangements of the generating plant in the various central stations on the Westminster system having been described, there remain certain considerations of general policy as regards distribution, means of securing constancy of supply, testing the circuits, the important relation of cost of generation to sale, as well as the manner of regarding the general accounts, which it will be interesting to mention.

The distribution is carried out on the usual three-wire system—a network of bare copper mains with middle neutral wire, run in concrete conduits, and fed by feeders from the dynamos at 225 volts. The two sides of the three-wire system are kept in balance for the large variations by occasional readjustments of house connections to one side or the other of the mains; and daily at the station by the use of the balancing machines, whose current is continually adjusted to supply the slight excess on either side of the mains.

The accumulators are kept constantly connected on the mains, so that no break in the supply is experienced. In times of light load during the early morning the accumulators take the whole service, the regulation being then, of course, accomplished by switching in a greater or less number of cells on either side of the network. The use of accumulators is testified to by Prof. Kennedy as having been "a great blessing." The only cost for maintenance is that of a few new plates, and the first cost, though greater than that for machinery of a corresponding output, is not found unreasonably high, while the convenience is enormous. By their use the plant at all stations is entirely shut down every night for some hours—as much as eight or ten hours (from 12.30 a.m. to 9 a.m. or 10 a.m.) in summer, and in winter from 2 a.m. to 7 a.m. The whole network of mains is connected together, and the stations at Millbank-street and Eccleston-place take the entire day load every alternate week. The networks are separated every two months for testing.

At each station the mains are tested every morning for earth; they are put to earth through a low-resistance ammeter by means of a flexible cable to a good earth made in one corner of the station, and the leakage noted. They are tested (1) for difference of voltage of each wire and the earth, and (2) for earth leakage. There is, of course, always some leakage to earth, but it is very slight indeed when it is remembered that there are 120,000 lamps connected in over 1,200 houses. The only occasion of a bad earth is when accidentally some company or vestry workman during the street repairs drives a pick into one of the armoured cables, which occasionally happens. A leakage of 100 to 150 amperes is thus sometimes set up when the mains are put to earth. When this occurs tests are taken at once to see which feeder is most affected: this will be the one nearest to the place of accident; the network at this district is isolated and tested with a testing set, the leak is found and the cable repaired.

With regard to the important question of earthing the wires, it is interesting to note that Prof. Kennedy finds the tendency in a three-wire system is for the negative main to get to earth potential. On first installation, when there were few connections, it was irregular, and fluctuated on either side. The middle wire for some time tended to get to earth, and Prof. Kennedy was long urged by the authorities to put the middle wire to earth, but refused, and, as it seems, with reason. The current at last adjusted itself definitely, and the tendency uniformly now is for the negative main to go to earth potential. This is so even if the mains are changed over. Mr. Monkhouse, superintendent of mains, has opened, for instance, a culvert where the negative is practically at earth potential, and the positive is 200 volts above earth, and he has then changed over. In 24 hours there will be no earth at all, and in three or four weeks the earth will go over to the other side—that is, to the then negative main. This seems to be an interesting feature worthy of note by electrical engineers, but of which the explanation is not easy to suggest.

The mains, in practice, are not found to give the least trouble with corrosion. There is no eating away of the copper perceptible after several years of use. The bare copper strip simply gets blackened and discoloured, but the surface remains smooth, and there is nothing that can be felt with the fingers to show any signs of incipient corrosion. There is absolutely no complaint on this score.

NATURE OF INSTALLATIONS.—The varying consumption for different classes of installation is a point of much interest to electrical engineers. By the kindness of Prof. Kennedy and the directors of the Westminster Corporation, we are able to give definite information in tabular and graphical form as to the varied rate of consumption during the different periods of the year in various installations supplied in the Westminster district.

It is, of course, somewhat difficult accurately to tabulate all the different installations in exact classes; but the classification adopted is sufficiently detailed to give useful information and guidance. The kind of installation in the Westminster district using the most current is that of public lights in the corridors of mansions. Clubs come next in the extent of consumption per lamp, and then hotels; after these shops, offices, flats, houses, and churches, in the order named. The following is the amount of

current consumed during the year 1892, expressed in units per 8-c.p. lamp per annum:

Nature of installation	Total units per 8 c.p. lamp per annum.
Public lights	51·7
Clubs	45·8
Hotels	38·4
Shops	17·2
Offices	16·1
Residential flats	13·6
Private houses	9·7
Churches	8·8

Rather a striking point in this table is the comparative smallness of consumption per lamp in private houses; it is only two-thirds that in offices, and but little over the last class—churches—where naturally one would expect the consumption to be small. House-lighting apparently is not so remunerative as most other installations, but the apparent anomaly is doubtless due to the fact that in private houses many more lamps are installed than are intended to be kept in constant use, which causes the average consumption per lamp to appear very low.

Cost of Generation.—We now come to the last and most important item, of the relation of cost of generation to sale of current. Taking the question generally, there are four chief heads under which the expenses of running an electric light company will fall:

1. Cost of generation—comprising salaries of engineers and staff, repairs, fuel, and general charges pertaining to generation and maintenance.
2. Central expenses—directors' fees, office salaries—not engineers', law, etc.—charges pertaining to revenue.
3. Rent, rates, and taxes.
4. Depreciation, and other charges in the discretion of the company.

These items added together and subtracted from the total revenue will give the profit.

It would be well if all electric light companies and municipal bodies working electric installations would agree on one model form and method of charging their accounts. There are several items of a fluctuating nature, which often are obscurely stated in the published returns.

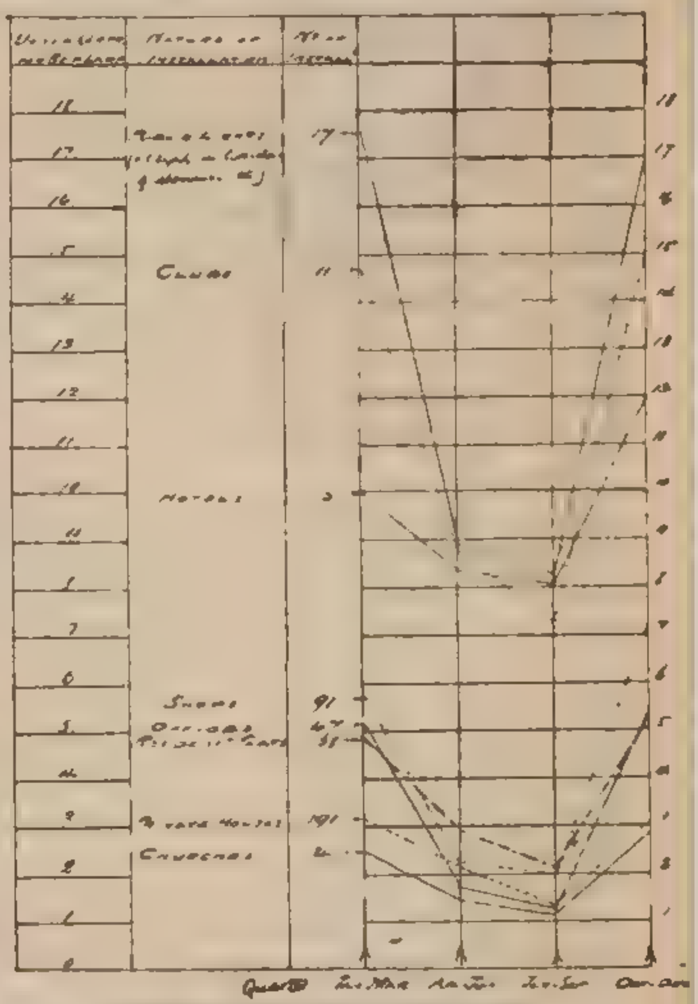
In Item 1, "Cost of Generation," for instance, should be reckoned all engineers' salaries (chief and resident), as well as the wages of the working staff. The engineers are clearly only required for the proper generation and supply of current apart from commercial considerations, and should be so charged. Several companies, however, wrongly include chief engineer's salary in the general expenses.

The cost of generation, which in the Westminster Corporation amounts to 1·08d. per unit, may be considered in two parts: (a) that part which can be influenced by the engineers-in-charge and the staff—such as coal, oil, water, waste, and repairs—and (b) the part which cannot be so influenced—viz., wages and salaries. On the part (a) of the cost of generation, a bonus is allowed by the Westminster Corporation to the staff on all profit or saving after a certain amount. The chief engineer estimates at the beginning of the year the cost of generation per 1,000 units, and 10 per cent. of any saving over this is distributed to the staff in proportion to their salaries. This bonus sometimes equals a full extra week's wages at the end of the year—a very acceptable present, and one which gives the men an interest in the schemes of economy promoted by the engineer.

With regard to Item 2, this includes all general salaries, expenses, and fixed charges not included under rent, rates, and taxes, with the special exception of chief engineer's salary, which, as above mentioned, is often lumped among other salaries, to the apparent lightening of the cost of generation; but as his great function is to lower the cost of generation his fees really constitute a charge on that item, and not on general expenses.

Rent, rates, and taxes, again, are sometimes not fairly charged. If the site is freehold the rent may be left out of the accounts, but this is clearly not good accountancy. The company in that case would be their own landlord, and the item rent should appear at its correct value.

Over the last item, "Depreciation," many discussions have been waged. There are two difficulties to be considered: the plant must be kept up to a state of full efficiency and therefore it may be considered that proper repairs and maintenance keep the machinery to its original point—as, for instance, railway rolling-stock is kept. But on the other hand, machinery not only depreciates in working: it goes



Distribution of Output between Four Quarters, 1892.

out of fashion. Engineers and inventors do not stand still, and the machinery may have to be taken out and replaced. Even if in as good condition as at first, its value depreciates, and a fund must be kept to guard against these contingencies. This question of depreciation is of special importance in comparing the installations of companies and public corporations. The town councils, having borrowed money for 30 years at 3 per cent., write off depreciation so fast that at the end of the time all the plant has been paid off and stands in the capital account at £ nil: this the companies, having dividends to consider, cannot afford to do.

We will conclude this account of the Westminster Corporation by giving the leading particulars of the working for the first half of this year. This electrical balance sheet is for a period of 25 weeks, which happens to correspond with their meter readings:

Electrical Balance-sheet, January to June, 1893 (25 Weeks).

	Total.	Percentage.
Units paid for by consumers	808,214	84·5
„ used for station lighting	18,600	1·9
„ used for meter testing	951	0·1
„ lost in batteries	10,485	1·1
„ expended in distribution	97,032	10·1
„ unaccounted for	21,544	2·3
Total units generated	956,826	100·0

		Per unit.
Income by sale of current	£20,979	6·23d.
Meter rents	857	·26d.
Total	£21,836	6·49d.

The maximum charge to consumers for the first quarter was 7d. per unit, and for the second quarter 6d. per unit. It will be seen that the average income for the half-year was 6·23d. per unit.

The following are the station costs for the half-year per unit paid for by consumers.

Salaries	0·212d.
Wages	0·625d.
Fuel	0·768d.
Stores	0·069d.
Oil	0·049d.
Water	0·081d.
Renewals and maintenance	0·226d.
Total	2·028d.

The weight of coal used during the same period works out to 7·38lb. per unit sold, as against 9·88lb. in the corresponding period of last year.

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.*

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

XIV.

(Continued from page 391.)

RESISTANCE, *continued.*

Siemens's Resistance-measurer.—A very ingenious modification of the differential galvanometer for the purpose of measuring resistances of varying magnitudes was devised by the late Sir William Siemens. Its main features are that the readings are made by means of a vernier on an equally divided lineal or circular scale, on which each division signifies a unit of resistance; that only a single unalterable known resistance is required, with the occasional employment of another for purposes of comparison and calibration; and that, as in the ordinary differential galvanometer, the readings are totally independent of the deflection-function of the instrument, the galvanometer needle being always brought back to its zero mark before a reading is taken.

The essential difference between this instrument and the ordinary differential galvanometer for measuring resistances is as follows: In the latter case the coils remain stationary, and the effect of the two currents on the needle are neutralised by altering the value of R_1, the known variable resistance, until the currents themselves are equal. The value of R, the resistance being measured, is then ascertained from the reading of R_1, which must be exactly equal to it.

In the Siemens instrument the value of R_1, and therefore of each of the two currents, remains constant during a measurement, and the effect of the two currents on the needle are neutralised by altering the position of the coils relatively to the needle until the effect of the stronger current, by reason of its greater distance from the needle, is just balanced by that of the weaker. The value of R in this case is ascertained by observing the position of the coils relatively to the needle.

Fig. 36 illustrates the principles involved in the construction and use of this instrument. The swinging needle is suspended just as in the ordinary differential galvanometer with its centre in the centre-line of the two coils, and its indicating pointer clear of them. The two exactly similar coils C and C_1, instead of being fixed to the baseboard of the instrument, are rigidly mounted on a sliding-bar B E which has sufficient movement in the direction of its length to permit of either coil being brought up close to the swinging needle. The sliding bar B E, which is supported on guide rollers, is provided with a pointed agate tip E which is kept continually pressing against the face of the inclined curve M N by means of a spring at the other end of the bar. Thus, if a downward motion is given to M N the sliding-bar and coils move to the left, and so bring the coil C_1 up towards the needle. If M N is moved upwards then the spring causes the bar and coils to travel to the right, the agate point following the curve, so that the other coil C moves towards the needle.

The inclined curve M N slides against a scale graduated in equal divisions, and is provided with a vernier to read to tenths of a scale division. The transverse motion of M N is obtained by means of a rack and pinion as shown in the illustration, Fig. 36.

The whole apparatus is mounted on a horizontal metal table supported by three levelling screws. The two coils, the suspended magnet, and the scale for observing the zero *of the pointer,* are all contained within a glass case, outside *of which are a contact maker, K, for* making and breaking the circuit, and six terminals—two for the battery connections, and four for coupling up the known and unknown resistances, R_1 and R. The connections are arranged so that the battery current is divided between two circuits as shown. One circuit contains the coil C_1 and the known resistance R_1, and the other contains the coil C and the unknown resistance R. In each of these two circuits is placed a current interrupter in the form of a plug, to allow of either or both circuits being readily broken when desired.

The calibration of the instrument consists mainly in determining the correct form of the curved surface M N. Theoretically, this could be obtained by calculation, using Weber's formula for the moment exerted by a current of known strength in a circular conductor, upon a freely suspended magnetic needle, but owing to the difficulties of constructing the coils accurately and of obtaining all the necessary data with sufficient exactitude, it is preferable to determine the form of the curve for each separate instrument empirically. To do this a carefully calibrated resistance box or rheostat is connected between the terminals provided for the unknown resistance, and a succession of positions of the agate point E are obtained, each corresponding to no deflection of the galvanometer needle for a different value of R. These positions are next marked off on the sliding-piece, to which successive transverse motions are given so as to make the scale readings correspond with the successive values of R, and the required curve M N is then drawn through the succession of points thus obtained. In practice Sir William Siemens used a similar method of calibration to this.

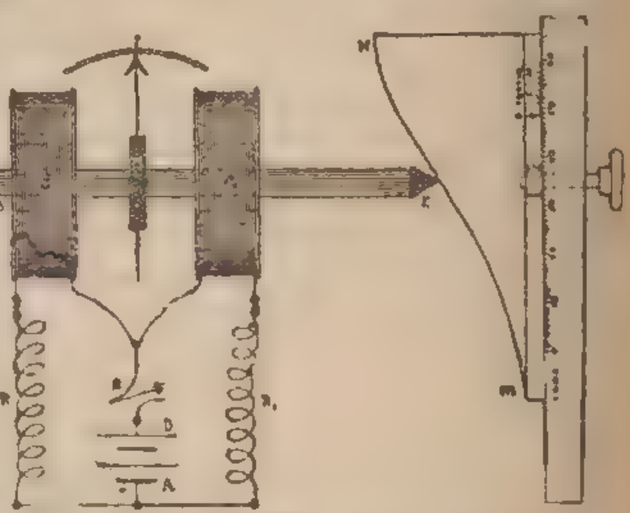


FIG. 36.—Diagram of Siemens's Resistance-measurer with Connections.

In addition to the single fixed known resistance R_1, which always accompanies this instrument, a second known resistance is generally supplied, so that check readings may be taken from time to time for the purpose of testing the accuracy of the instrument. This second known resistance is also extremely useful for readjusting the zero point after the instrument has been altered in any way, or if a new silk fibre suspension for the needle has been put in.

In practice the manipulation of the instrument is extremely simple. R the resistance to be measured is connected up between the terminals as shown, and the sliding piece M N is moved transversely by means of the rack and pinion until the closing of the contact-maker K causes no deflection of the galvanometer needle. The resistance of R in ohms is then read off directly from the fixed scale with the aid of the vernier on M N.

The device for adjusting the position of the coils can also be made so that the fixed scale and the sliding piece M N, instead of being flat, as in the instrument illustrated in Fig. 36, form part of the surface of a cylinder. A turning instead of a sliding motion must of course be given to M N in this case.

This instrument excels the ordinary forms of Wheatstone's bridge both in accuracy and range, besides being cheaper and much more portable. Both the range and the sensibility of the instrument can be varied within very wide limits by altering the dimensions of the coils and the form of the curved surface M N. It has been found of great

utility for the reading of resistance thermometers—that is, thermometers which depend for their readings on the variation of the electrical resistance of wires exposed to the temperatures being measured, and it has also been found of service, before the days of testing-sets, for the measurement of the wire resistance of overland lines.

(To be continued.)

MOTOR GEARING FOR ELECTRIC TRAMCARS.

(Continued from page 417.)

At the present time—and until, in fact, we are able to design electric motors for tramway work to run at extremely slow speeds (say, 80 to 100 revolutions per minute) with high efficiency (88 per cent. at least) and for powers as small as 10 h.p. to 20 h.p.—it may be assumed that a speed-reducing gear becomes essential in order to connect the motor and car axles.

But if the slow-speed motor should ever obtain this position, its features are in other respects such as will bring it at once to the front. Not only would it avoid the use of toothed wheels in any form between the motor and car axles, with all their attendant noise and loss of energy, but by mounting a separate motor upon each car axle—with a disc spring connection such as that devised by the Short Electric Company—all the car wheels may be used as drivers.

This step, of course, involves the employment of at least two, if not four, motors to each car; but any disadvantage thus occasioned—in first cost or expense of operation—may be balanced by the expense and losses of energy that follow from the necessary use of connecting or side rods, if, as in the Eickemeyer system, a single motor be placed centrally between the two car or bogie axles, driving the latter by a coupling-rod on each side. The chief advantage of the latter method, as compared with the use of motors whose weight rests directly upon the axles, is that it avoids the heavy "pounding" on the rails when passing over joints, the weight of the motor being carried by springs. Any comparison between the Short and Eickemeyer systems of arranging level geared motors must be based upon the respective efficiencies of one large motor or two small ones of total equal output, and also of side coupling-rods as opposed to a flexible spring coupling.

Returning, however, to the speed reducing gears as being those essentially of service under ruling conditions, these resolve themselves practically into two main types—first, those employing frictional resistance in the connecting gears; and secondly, those dependent upon the intermeshing of teeth in various forms. Of course, if we are to accept the statement that friction between two surfaces, as, for instance, a driving belt and pulley, is nothing more nor less than the intermeshing of extremely small protuberances on the respective surfaces, these two classes may as well be thrown into one; but for explanatory purposes, we shall with advantage retain the division.

In the first class of gears, those which have been experimented upon for electric tramway work are unable to lay claim to any great success. Apart from friction pulleys—such, for instance, as the proposed friction arrangement of two discs at right angles to give in addition a variable speed by moving one of them to or from the centre of the other, or the use of compressed paper pulleys to drive iron pulleys on the car axles (in both cases the pressure required to prevent slip being a fruitful cause of sprung axles)—the plan generally adopted has been to use ordinary link leather belting with double-flanged iron pulleys.

The idea of using a belt for power purposes where only a very short drive can be obtained, and where the conditions of working are likely to cover the belt with dust and dirt, would hardly appeal strongly to the mechanical engineer. In one instance, however, as stated in Table A (published last week), this type of gear has been successfully employed at Brighton, although it must be confessed that specially favourable conditions are prevalent, and also that worm gear has now been adopted for this line, which, moreover, does not involve the serious consideration due to a standard street tramway. Leather belting of this kind has for that matter, however, been used for some time in railway work, as on the London and Brighton line, for the reverse action of driving dynamos in the guards' vans for lighting the trains electrically, the driving pulley being mounted on the van axle. So far as railway and tramway conditions are comparable, it is therefore at least possible to make out an excuse for the existence of such a method of gearing, but not much more than this can be said.

Ropes of cotton worked in grooved pulleys, either separately or endless, with a jockey pulley for tightening, have also been suggested, but though serviceable enough in a cotton mill for transmitting 1,000 h.p. or more, and perhaps—though that is doubtful—in electric lighting stations where the unit of power is about one-fifth of this amount, such a method is totally out of place underneath a tramcar, and had better be put aside at once as unsuitable.

In one instance small cords of steel wire wound spirally and running on grooved pulleys (just as with cotton ropes), have actually been tried; they worked quite noiselessly, but were unable to transmit heavy sudden stresses owing to the slip between the two surfaces.

Turning now to the second class of gears, we come to the question of toothed wheels in some form or another, and here there are many types not only worth mentioning, but of value for the purposes of tramway work.

Probably the first kind of such gear to be used for this work was the straight-toothed spur wheel, and engineers have apparently ranged from this through all manner of devices only to return once more to its use. Since, however, we have seen that systems of double-reduction gear at first came generally into use, the excessive noise and waste by friction, etc., of four toothed wheels at least to every car—sometimes twice as many—led engineers to experiment with other types of gear for one or other of the two sets of wheels, and hence the chain and sprocket wheel came into service.

Although this method of gearing is doubtless much quieter than spur wheels, so long as the chain is comparatively new, unworn, and unstretched, yet as wear sets in chain gear becomes even more noisy and objectionable than toothed wheels, whilst it is much less easy to protect from dust and mud. The experience hitherto gained in this direction has not been such as would greatly recommend the extensive use of chain gear, even for the slow running of a second motion shaft in a double-reduction system. The average speed of the chain when thus employed would be probably about 500ft. per minute, which is well within the working limits of the hardened steel parts, for in some cases chain gear such as that made by Mr. Hans Renold, of Manchester (who designed and furnished chain gear for the Bessbrook and other tramways), has run without difficulty at a speed of 1,000ft. and even 1,500ft. per minute.

No trouble is experienced with this type of gear from want of strength, but the great wear and tear has proved the chief obstacle to its use. Mr. Renold now insists on as much consideration being given to the wheels as to the chain, and he makes the driven wheel alone equal in pitch to the chain, that of the driver being much greater. That is, the spaces between the teeth on the driver are considerably wider than is just sufficient to enable the chain rollers to embrace and leave the teeth.

In spite of these recent improvements in chain gear, it seems hardly likely, however, that it will come into extensive use for electric tramway work, when its failings are compared with the greater simplicity and ease of operation of spur gear. Several forms of the latter have been used on electric tramcars, as may be seen from the table given in the last article. The favourite kind, however, appears to be the straight-toothed wheel, the pinion or motor axle wheel of bronze, and the large car wheel of cast iron. These materials are, of course, capable of variation, and they are often in consequence varied largely according to the fancy of engineers. Thus, we may find any of the following combinations at work:

Pinion.	Large Wheel.
Best hammered steel.	Cast steel.
Phosphor bronze.	Steel.
Raw hide	Cast iron.
Raw hide and steel—built up in alternate discs.	Steel.

In the majority of cases the pinion wheel teeth—if not those of the larger gear wheel—appear to be machine-cut; and the easier running thus to be obtained is almost worth the expense of cutting, or, at least, machining the teeth of cast wheels also. In order to avoid the noise and shock at starting or going backwards, when the teeth of spur gears engage with one another, the double helical type has been introduced in one or two instances, with excellent results; and two of the most recently-equipped lines—Birmingham and South Staffordshire—it will be seen are provided with this form of gear on the cars. The first cost is, of course, greater than that of ordinary straight-toothed wheels, but the running is much "sweeter" (as engineers say) and easier: this is due not only to the V-shaped form of tooth when seen edgeways (by means of which there is obtained, for equal widths of rim, a contact or wearing surface much greater than with the straight-toothed gear), but also to the care necessary in making and cutting the wheels so as to ensure accuracy of fit.

An ingenious arrangement of straight teeth has been proposed by American engineers for the purpose of obtaining equally good results in running: this idea comprises practically the fastening together side by side of two ordinary straight-toothed gear wheels, but with the teeth of one slightly in advance of those of the other. This "staggered" arrangement, as it is called, resembles exactly the effect given on the Abt system of rack railways, where a toothed pinion with one, two, or even three sets of teeth, set one in advance of the other, gear into a rack placed on the ground and composed similarly of one, two, or three separate toothed bars, the teeth of each bar being placed respectively opposite the spaces of the next, and so on.

This type, however, whilst undoubtedly ingenious, has not come into use at all. It would be cheaper to make than the double helical gear, and has the advantage of affording a comparatively large width for the gear wheels; but it also implies bolts and nuts, or other such unmechanical and undesirable fastenings for securing the two half wheels, unless they be cast in one, in which case the cost of cutting the teeth would be about as much as with the double helical gear, whilst the working results would prove less satisfactory.

(*To be continued.*)

WHAT IS ELECTRICITY?—V.

BY SYDNEY F. WALKER.

THE LINK BETWEEN ELECTRICITY AND MAGNETISM.

The writer had intended to defer the continuation of his articles on this subject until the book on which he is now engaged had been safely piloted through the press, but having the good fortune to be present at a lecture by Prof. Ewing, in which he explained his theory of molecular magnetism, and illustrated its working by means of the beautiful models that he has arranged for the purpose, the after study of the subject led the writer to attempt the solution of what he has always regarded as one of the most difficult problems in the task he has set before him.

As readers of the *Electrical Engineer* will know, it is sometimes comparatively easy to formulate a theory, but very difficult to follow that theory wherever it leads, and still more difficult to account for every known phenomena by means of it. To the earnest student of electrical phenomena, the connection between electricity and magnetism must always be exceedingly puzzling.

The results obtained by the development of magnetism are in nearly every case totally unlike those obtained from the generation of electricity, except when bodies possessing the one form of energy are used to generate the other form—in other bodies—and yet each may be used to generate the other, and may be transformed into the other at will. What, then, is the connection between the two forces? Prof. Ewing very properly lays the greatest stress on the fact which he has discovered, that in the phenomena known as hysteresis energy is actually consumed—so far as energy can be consumed—in the act of turning the molecules to and fro upon their several axes. That is to say, energy *imparted to the molecules* by the electric currents passing in the magnetising coils is first transformed into mechanical energy, and then into heat. But this, in the writer's opinion, furnishes the clue to the connecting link that we are seeking—the link joining the two forces.

In order to grasp the idea that the writer has formed on the subject, it will be necessary to make a somewhat bold, but, he believes, a grand conception. When the atoms of what we know as our earth, the planets, our sun, and the other heavenly bodies, were passing from the gaseous or nebulous state to the solid, each group of atoms combined in some particular manner, forming themselves into certain substances, according to the conditions surrounding each group and the forces acting upon them, and so the different chemical elements, with their different properties, came into existence. These properties would depend apparently on two things—the quantity of energy absorbed in each group of atoms, and the manner in which the energy was stored. This last—the manner in which the energy is stored—the writer takes to be simply the rate and form of the vibrations of which the energy stored in each element is composed. Thus, in the substance we know as zinc, the energy stored will consist of molecular vibrations at a certain rate, and in a certain manner—the molecules covering a certain path. In iron, the energy stored will consist of vibrations at a different rate from that of zinc, and again with a totally different path for their motion. In copper, again, the motion would appear to be at a different rate from that of zinc and of iron, and with a path differing from either, but more like that of zinc than that of iron. It follows, if the above be correct, that what we know as chemical affinities are really only such affinities of vibration as we are familiar with in the case of sound.

As every student of acoustics knows, columns of air, say, enclosed in long jars, will only respond to particular notes that are communicated to them; to all others they are apparently dumb. So it would seem that when we say that zinc or iron has a strong affinity for oxygen, we merely mean that the periods of their vibrations—and the paths which their individual molecules take—are such as will readily coalesce to form what we call another substance, but which, if the motions were larger and those of bodies that we could see, we should call taking the form and the period of the resultants of the two motions.

Amongst other points, it may be noted that each substance, however simple, or however complex, has the property of selecting what portion of heat or light rays it will absorb and what portion it will reject, the latter portion determining by what colour, as we term it, the substance shall be known to the human eye. Of course we know that by colour we merely mean that the rays of light reaching our eye from a given body are vibrating at a certain rate. But it would appear that this question of colours like that of chemical affinity, and like that of columns of air, stretched wires, etc., is merely a question of the rates and the forms of vibration of the body upon which the light rays fall, and such of those of the light rays themselves as are able to coalesce, and that the colour and form assumed by the body is due to the resultant of these vibrations to the resultant rate and path taken by the molecules of the body. Colour contrasts and some of the well-known optical delusions well illustrate this. Among the numerous forms taken by different groups of atoms and their numerous properties, iron and its alloys, with cobalt and nickel, appear to have conferred upon them the peculiar property we know as magnetism—viz., the property of being double-ended—the two ends having opposite qualities, and the property of dissimilar ends attracting each other. This the writer conceives to be stored energy in the form of a vibration of a special time and form peculiar only to those bodies—iron, nickel, and cobalt—but more especially to iron. Oxygen, as we know, possesses magnetic properties in a very small degree, and it is a striking fact that one form of oxide of iron, Fe_3O_4, also possesses this same property, while the other compounds that iron forms with oxygen and with other elements do not. The writer interprets this fact thus: The molecules of the iron when pure, or when alloyed, are in a state of vibration at the special rate and in the special manner which gives rise to polarity and attraction between dissimilar poles. When combined with a certain

quantity of oxygen, that contained in the magnetic oxide, the resultant rate and form is sufficiently near to that of the iron itself to enable the molecules to respond to the force exerted by other magnets, though not so readily as iron would. When other proportions of oxygen or other elements are combined with the iron, the rate and form of the vibrations are so altered that they do not respond to the vibrations emitted by magnets, and have lost the magnetic properties. It appears to the writer that it is probable that magnetic vibrations within any magnet, or within any molecule of any magnet, are in the form of continuous waves from one end to the other, these waves being taken up by the ether surrounding the magnet or the molecule, and from it communicated to the next molecule, or to another magnet or another piece of iron, as a pushing or pulling force—what we call lines of force being merely the communication by the ether of this pushing or pulling force—the ether itself, of course, vibrating in unison with the magnet or the molecule it proceeds from.

Then as to how electricity is connected with magnetism. If Prof. Ewing's theory of magnetism is correct—and, as we know, it answers for all known phenomena—if we impart energy, or, in other words, molecular vibrations to the molecules of an iron bar, in a suitable manner, in a manner that they can accept, they are obliged to release themselves from their previous attractions for other molecules, turn themselves round in a particular manner, and send off their lines of force, their pushing and pulling forces, in front of and behind them. What takes place is, in the writer's view, the molecules of iron take up a position which is due to the resultant of the two sets of vibrations—those present in the molecules before the act of magnetisation, and those impressed by the electric current; both, of course, being modified by the vibrations of surrounding bodies. What the electric current does apparently is to communicate this energy to the molecules of iron, nickel, or cobalt, just in the form in which it will do that particular work within the bar—viz., the twisting of these molecules and the sending out of their pushing and pulling forces into the ether surrounding. The rate and form of vibration imparted by heat, as we know, not only will not effect this, but will actually extinguish the magnetism when already created, the resultant rate and form of the vibrations being evidently such as will not respond to the magnetic pushing and pulling forces.

We do not know whether the form of energy we know as sound can be converted into magnetic energy. Probably it can, but only after first being transformed into some other form. From mechanical energy in the form of impact, as we know, we can obtain a slight degree of magnetisation; but it is electricity that gives us the best results, because apparently its rate and form of vibrations are so allied to those impressed upon the molecules of the iron at their birth that the resultants of the two create the pushing and pulling forces we know as magnetic repulsion and attraction.

But how does the electric current do this? The writer has not yet dealt at length with the phenomena of electrical conduction in this series of articles, but it may be stated shortly that his view is that what we call conduction is merely the transmission of the vibration he conceives electricity to be, continuously through the mass of the conductor, and electromagnetism he conceives to be its transmission in waves surrounding the conductor. As he understands the matter, the transmission within the conductor is only a part of another wave, the difference being that the wave within the conductor proceeds onwards at a very different rate to the waves surrounding the conductor, while the waves surrounding the conductor and emanating from it are influenced by the rate and form of the vibrations already present in the molecules surrounding the conductor.

Given, then, a conductor, with a current passing through it, and a piece of iron in its neighbourhood, it will be remembered that the iron, if it is to be properly magnetised, must occupy a certain position with reference to the conductor. Waves of vibrations emanate from the conductor, circling round it in larger and larger circles, and on arrival at the iron, impress upon its molecules some of the energy of which they are possessed, and gradually as the molecules become possessed of more and more energy, more and more vibrations—now at a different rate and of a different form to that with which they were created—obliging them to turn round on their axes and to send out the push and pull vibrations already referred to, or, as we say, to become magnetic.

EPSTEIN ACCUMULATORS.

The following report, dated the 24th June, 1893, has been made by Messrs. H. Alabaster, Gatehouse, and Co. on the Epstein traction accumulators :—

The Epstein accumulators are formed by direct oxidation without the use of paste; they are simple, easily managed, and apparently very reliable; the plates are very strong, and few in number, the reduction of the component parts constituting a great advantage, especially when employed for traction work.

Two sets of tests have been made—with a five-cell traction battery hermetically sealed to prevent the escape of solution, and on a one-cell accumulator (open) supplied to show the construction of the cells in the five-cell battery. The plates are of the Planté type of substantial construction, having their surfaces grooved, thereby increasing the active surfaces of the materials.

The following are the particulars of the open cell :

	Weight lb.
One positive plate, 19⅝in. by 8in. by ⅜in.	14
Two negative plates, 19⅝in. by 8in. by $\frac{5}{16}$in.	17½
Ebonite cases, 21⅞in. by 11in. by 2in. by ⅛in.	3½
Solution	12
Wood box containing ebonite cell (this is not usually supplied, and the weight should therefore be deducted)	10
Ebonite insulators	½
Total	57½
One five-cell traction battery	244
Average weight per cell	48·8

These cells, which were represented as being capable of developing 90 ampere-hours at a 30-ampere rate, we received ready charged on June 16, 1892, and remained at rest until September 7, before the first discharge, when they were joined in series and gave out 71·273 ampere-hours and 801·494 watt-hours. They then received one charge of 100 per cent. more current than their specified output, followed by a series of discharges at 30 ampere rate, and charges of 5 per cent. above their output at the same rate, until September 10, when after a charge of 95 amperes and 1,291·4 watt-hours they were left at rest until November 18 (during which time no special care was taken to insulate them), when they gave out 55·65 ampere-hours and 600·59 watt-hours, being 55·59 per cent. quantity, and 45·51 per cent. energy efficiency of the charge they received on September 10. This was followed by consecutive tests, terminating on November 24.

The following is the mean of the observations made during the two experiments :

Charge		Discharge		Efficiency		
Ampere-hours.	Watt-hours.	Ampere-hours.	Watt-hours.	Ampere-hours.	Watt-hours.	Dates.
94·9	1,367·92	89·72	1,058·80	94·58	77 69	Sept. 7-10
94·8	1,351·63	91·42	1,058 99	96·44	78·44	Nov. 18-24
		Mean 90·57		176·50 per cell.		

It therefore follows that

176 5 watt-hours corresponds to 5·605 watt-hours per lb. of combined + and – plate.
" " " " 12·61 " " of + plate.
" " " " 3·618 " " of cell.

And therefore—

30-ampere rate corresponds to 0·9528 ampere per lb. of combined + and - plate.
" " " 2·143 " " of + plate.
" " " 13·51 " " sq. foot + plate.
" " " 13·51 " " " – plate.

It will thus be seen from these results that so far as regards the behaviour of the accumulators when at rest, they act in every way as represented by Mr. Epstein, even to the remarkably good results obtained after long intervals of rest, and they confirm the very favourable report made on the Epstein accumulator, in July of last year, by Prof. W. E. Ayrton, F.R.S.

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CONTENTS.

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HONOUR TO WHOM HONOUR IS DUE.

To-day the patent for the incandescent lamp expires. Although the general feeling may be one of thankfulness that now these lamps will be placed on the market with only trade profits, there must be another feeling amongst the few who wonder how far the anathemas of competitors mislead the world. As electrical engineers, let us consider for a moment what has made our industry possible—yes, possible; for without two patents the industry would not exist. If it were useful, we might fill a whole number with opinions expressed by prominent men as to the possibilities of electric lighting prior to 1880. A careful study of the Blue-book issued in 1879, containing the evidence before the Select Committee of that year, will sufficiently prove the case we bring forward. The birth of an electrical industry is due to M. Gramme. Whatever credit we may give to the constructors of magneto and dynamo machines before Gramme will not affect the fact that he was really the first to construct a machine to suit all practical requirements. But the machine of Gramme would have failed to build up an industry had not Swan and Edison come forward with an incandescent lamp. The development of the Gramme dynamo combined with the development of the incandescent lamp has given us an industry the bounds of which are in the unknown. Ought we to grudge Gramme the money value of his patent, or ought we to grudge Swan and Edison the money values of their patents? Whatever these men have received—and doubtless it is much less than the world generally supposed—it is no more than their due. We say the amount is less than one generally supposes, because a close examination of the facts will show that so far as the Swan-Edison Company is concerned, prosperity did not dawn for them till the second half of the period during which this patent that now lapses had run. The memory of the world is short. The gratitude of shareholders is shorter. An extra half-year before dividends are paid is enough to cause dictionaries to be ransacked for adjectives to throw at directors; a diminution of dividend, and the same state of things prevails. As electrical engineers, our readers are mostly neither directors nor shareholders, and can therefore without company feeling join in the praise of men who have made possible an industry which numbers them within its borders. We can express a hope that the pecuniary reward these inventors have reaped has proved satisfactory to them. The life of a successful inventor is not altogether to be envied while his patents run. The world has no soft words for him: he is everything bad that a vocabulary can be made to indicate. His friends praise him to his face for what they can get, while his would-be competitors think burning at the stake a mild correction. Could Messrs. Swan and Edison have collected the sweet words uttered because of their so-called bloated monopoly, the collection of language would be unique.

It will be unnecessary to expatiate on the condition of the industry now; let us briefly examine the state in 1879 as portrayed by the Blue-book. We find in the appendix pictures of

Gramme machines, of Lontin's machines, of Jablochkoff's lamp, of the Rapieff lamp, and of the Wallace farmer machine and lamp. Where are these, except the Gramme, in fourteen years? In the two hundred and forty odd pages of the Blue-book there is no mention of an incandescent lamp such as we know it. A few of the questions and answers will be interesting. Thus Prof. Tyndall in his evidence:

50. Supposing that you have a light produced by one current, say of ten thousand candles, can you divide that into ten lights of a thousand candle-power each from the same electric current?

I do not think so.

51. In fact, at the present moment there is nothing, either in science or in practice, to show that you could do that without loss?

I think not.

The late Mr. C. W. Siemens gave the following replies to questions:

259. Has your attention been called to some of the more recent experiments of Mr. Edison, and to the success which he is stated to have achieved in subdividing the light, and making it applicable for rooms and dwellings, and so on, with great ease and cheapness?

I have, and I think Mr. Edison can, no doubt, produce by his means a very steady and possibly an agreeable light.

260. And a cheap light, he claims, I believe? Dynamically speaking, I think he has to prove his case as yet.

Our experience, as far as I can judge from my own, leads me to an opposite conclusion.

297. You would say that for such purposes as footlights and sidelights, which require constant modification of the light, at present at any rate, whatever your experience may lead you to in the future, the electric light is hardly a suitable light?

Such a light, for instance, as Mr. Edison proposes now, I think would be much more controllable in that respect than the electric arc. The electric arc cannot be varied in its intensity and brilliancy so readily as gas; but if the light is produced by igniting a piece of iridium or platinum wire, then it is easy enough to modify the current so as to give only a small amount of radiated light.

298. But up to the present, at any rate, lighting with platinum or iridium has hardly gone beyond the experimental stage?

Certainly not.

Mr. Conrad Cooke said:

425. Dr. Siemens, in referring to Mr. Edison, who is credited with having recently invented a machine for subdividing the light, expressed some doubt on the subject, and stated that he thought that it was not as promising as the reports indicated. Do you know anything about that?

We really know very little at all about it. A few newspaper paragraphs have appeared on the subject, and I have been very much interested, as everybody has. His nephew told me himself that he has seen, I think, over two hundred lights on one circuit. I must say I should like to see it myself, and that is all I can say.

Mr. W. H. Preece said:

541. Speaking of the lighting of a street of 1,000ft. long, your estimate was that forty lamps of fifteen candles each, giving a total of six hundred candles, would light the street better than one electric light of six thousand candles?

So my calculation comes out; but, as I say, it is so startling, and so curious, that I am also inclined to think that there must be some mistake somewhere. I have got it nearly ready for the *Philosophical Magazine*, but it is so curious that I do not like to publish it unless I verify it a little further.

We will not multiply quotations further, but simply state that throughout the evidence there is no indication of certainty of what was then termed the subdivision of the electric light. All the evidence which contained no uncertain sound was to prove the suitability of the arc light for almost every purpose—to praise it as the forthcoming light, and to contend that it would prove to be divisible and useful for interiors as well as for exteriors. Those doctrines are now exploded—they were exploded before the next report issued by Parliament of the Select Committee in 1882. In fact, the question was practically solved in 1879, but none of us knew with certainty. Rumours, fast and furious, flew about, but the incandescent light was not seen by any of the moving spirits in the Select Committee till months after the issue of the report. Fourteen years have passed since November, 1879, and what a fourteen years in the history of electric lighting! What is the number that owes daily bread to Swan and Edison? Arc lighting no doubt would have developed, but its powers to create an industry would have been small compared with those of incandescent lighting. Therefore, while being thankful that the end of the patent monopoly has come, and that the manufacture is open to the world, we should not forget nor be slow to admire the work of the men who made these things possible.

ELECTRIC FIRE-ENGINES.

Most of our readers will recollect that a fire-engine worked by an electric motor was exhibited at the late Crystal Palace Exhibition. We think it was one of Messrs. Siemens's motors, but at any rate it was daily shown in action throwing water to the Palace roof. The idea seems also to have reached America, though there the prior work in England seems to be unknown or ignored. If, however, the energy of our cousins on that side causes more attention to be paid on this side to an application of the utmost importance and simplicity, we shall not complain. It is extremely difficult to convince users of any apparatus that improvement is possible. They know what the old will do, and prefer to let someone other than themselves try the new. What are the advantages of an electric fire-engine, and where might it at once be useful? We think the advantages very great; it would be cheaper, would be lighter, would be

smaller, would work without fire and smoke, and be quite as effective as the steam fire-engine. It might with advantage be obtained for factories requiring an engine and running their own electric light installation, or for areas where electric current could be obtained from street mains. There would be no getting up steam, but simply the pushing home of a plug into proper contact-pieces. These fire contact plugs could be as numerous as the junction-boxes in an electric light system—more numerous if desired—and add little to the cost of the electric mains, and interfere nothing with their efficiency. Electric lighting is becoming so common and so largely supported by local authorities, that when the question of a new fire-engine arises it might be well to consider the one worked by an electric motor. Perhaps the difficulty of motor comes in. Some authorities use a continuous current, some an alternate current, and ordinarily a motor will be constructed for use by one or the other, not for both; but there are motors said to work equally well with either kind of current. Therefore, if such motors can be constructed of the size required, one obstacle is removed. It will be well if manufacturers keep this application of electricity in view, and push what may prove a most lucrative branch of business.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ELECTRIC TRAMWAYS.

SIR,—Though the era of electric traction as applied to tramways has not yet begun in England, it nevertheless ... reached a very critical stage in its history. The recent decision of the Parliamentary Committee on earth returns has opened up the way, and some development of electric traction may reasonably be expected. The results of the early attempts will be watched by tramway managers with interested not severely critical eyes. The extraordinary success which has attended the introduction of electricity on the street railways of this country has led English electricians to lay before the tramway managers very sanguine estimates of the effect of supplanting horses by electricity, more especially as regards the cost of running the cars. Should these early attempts not meet with the success so confidently predicted, the confidence of the tramway officials will be almost irretrievably undermined: they will come to the conclusion that the claims advanced for the cheapness of electric cars are on a par with those so often and so recklessly advanced for the cheapness of the electric light, and it will not be much use talking electricity to them then for some few years to come, nor will elaborate explanations as to why these particular lines were unsuccessful carry much weight with them. It is not, therefore, without reason that I have said that the present time is critical. A mistake now would be well nigh fatal, but, fortunately, we have one great precedent to guide us—America. Are we going to avail ourselves of the varied experiences so dearly bought by that progressive country, and now laid gratis at our feet, or are we going to let our national pride intervene and send us groping blindly in that unknown region that is studded with expensive pitfalls, are we, in fact, to work in series with America, or in a kind of belated parallel? This is an age of common sense, and I think we shall choose the former alternative.

To what points, then, shall we turn our attention? By far the most important is the absolute supremacy of the trolley. When I first came to this country I had a vague idea that there were several systems of electric traction—trolley, conduit, and storage batteries—and that none could be said to have gained the victory over the others. This was, I believe, the opinion prevalent in England at the time, and so far as I can judge seems to be so still. Only a few weeks ago, the *Electrical Engineer* in an editorial recommended the use of the conduit system for a part, at least, of the Leeds tramway system. I do not like to say that this suggestion was little short of criminal, as that might be looked upon as an exaggeration, but it would not be far, nevertheless, from expressing my opinion. What has been the experience of the rest of the world in the matter? The history of the trolley in this country has been one triumphal march from Maine to California—or perhaps I should say from California to Maine. Throughout all the land there is scarcely a town of importance that is not enlivened by the peculiar buzz of the passing trolley; the financial results, needless to say, have been equally satisfactory, otherwise the system could not have grown as it has. Five years ago the trolley was practically unknown in America: to-day one might almost say there is scarcely anything else; and in trying to grasp this statement it should not be forgotten that whilst in England only large cities have any tramway accommodation at all, in this country every village has it, or must be content to tolerate the ridicule of its neighbours.

In striking contrast is the history of the conduit and the storage battery. Here, as elsewhere, there is a strong opposition to the introduction of the overhead trolleys into a city where they have not previously had any, though none object afterwards, as they are then compelled to realise how greatly the advantages outweigh the disadvantages. This opposition has resulted in the devotion of an immense amount of time, ingenuity, and capital to the perfection alike of storage battery and conduit, yet there has been nothing but failure; occasionally a storage battery car runs successfully, extravagant claims are made; the Press, especially the lay Press, enthuses, and then the storage battery car passes out into that oblivion where many a storage battery has preceded it, and the trolley quietly takes its place. The conduit has been tried again and again, and though run by men of long experience in the electric railway business, it has been even less successful than the storage battery. I know of only one conduit road now running in this country, that at Washington, and that has not yet passed through a winter. The Budapest road is the solitary example of success that has crowned the efforts of those who have pinned their faith to the conduit. Whilst, then, the trolley has proved, I think I am justified in saying, the most extraordinary success in the history of the commercial world, the history of its rivals is nothing but a succession of gloomy failures. It is, therefore, with all the emphasis in my power that I protest against the use of either storage battery or conduit at this critical time. Should the conduit be introduced, its unreliability, its great cost, both initial and running, will bring almost inevitable failure in their train, and electric traction will have received a blow under which it may well reel.

Another point to which I wish to direct attention is the voltage. I think a determined stand should be made before the Board of Trade to induce them to allow the use of 500 volts. I do not think the Board of Trade are as old-womanish as some would have us believe. Is it realised that the electric cars of this country are carrying passengers at the rate of many hundreds of millions (about 900,000,000, I believe) annually—that is to say, about the same number as all the steam railroads of England put together—that the voltage is universally 500, and that no one has ever yet been killed by a shock from a trolley wire; indeed, it is a matter of common knowledge to electricians that a 500 volt shock, though anything but pleasant, is in no way dangerous. Now, all this is no mere theorising; it is the everyday experience gained in the transportation of countless millions. I think that if this state of affairs were put fairly and squarely before the Board of Trade, they could not but consent to the use of 500 volts.

These are but a few of the many points upon which I could enlarge, but I fear I have already trespassed greatly on your space, for which the vital importance of the subject must be my excuse.—Yours, etc.,

Detroit, Mich.

NORMAN WHICHELLO.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE IV.

(Continued from page 436.)

High and Low Pressure Systems.—Systems of hydraulic transmission are of two distinct types. First, there are systems which, for convenience, may be termed low pressure systems, with reservoir storage. In these the working pressure is fixed by local conditions, especially by conditions determining the site for the reservoir. Generally, the pressure is not more than 400ft. to 600ft. It is the reservoir storage in these systems which more than anything else, makes them suitable for the supply of power for all ordinary industrial purposes, for driving factories or electric light stations, for instance, involving a large continuous demand for power extending over considerable periods of time. Secondly, there are systems which, for convenience, may be termed high pressure systems, with accumulator storage. The pressure in these systems is usually 700lb. to 800lb. per square inch, or 1,600ft. to 1,800ft. of head. These systems, in which the reserve of energy is limited in amount, are most suitable for working cranes and lifts, hydraulic presses, and similar intermittently working machines.

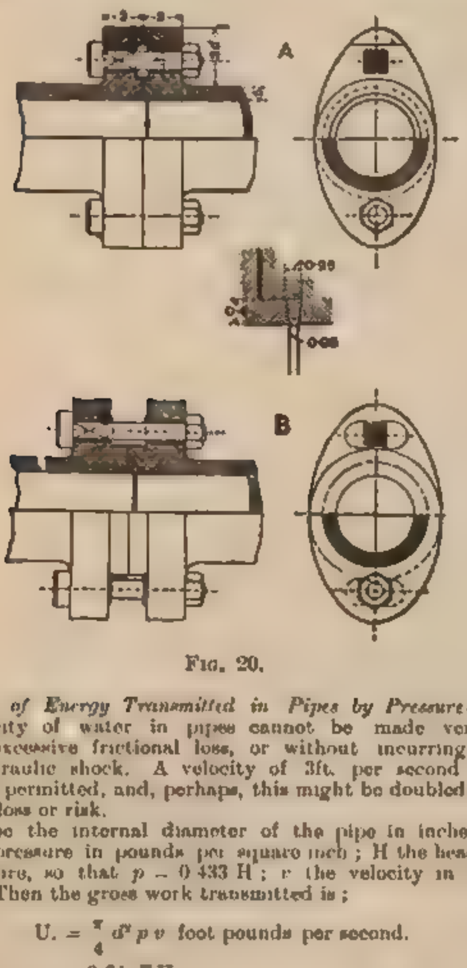


FIG. 20.

Amount of Energy Transmitted in Pipes by Pressure-water.—The velocity of water in pipes cannot be made very great without excessive frictional loss, or without incurring danger from hydraulic shock. A velocity of 3ft. per second is very commonly permitted, and, perhaps, this might be doubled without excessive loss or risk.

Let d be the internal diameter of the pipe in inches; p the working pressure in pounds per square inch; H the head due to the pressure, so that $p = 0.433$ H; v the velocity in feet per second. Then the gross work transmitted is;

$$U. = \frac{\pi}{4} d^2 p v \text{ foot pounds per second.}$$

$$= 0.34\, d^2 H v \quad ,, \quad ,,$$

or in horse-power—

$$H.P. = .001428\, d^2 p v$$

$$= .000618\, d^2 H v$$

GROSS HORSE-POWER TRANSMITTED BY DIFFERENT MAINS.

Low Pressure System.—Head, 500ft.

Diameter of main in inches.	Gross h.p. transmitted.
9	73
12	133
18	300
24	533

High Pressure System. Pressure, 750lb. per sq. in.

Diameter of main in inches.	Gross h.p. transmitted.
3	29
6	116
9	260
12	463

At 3ft. per second, and with a pressure of 500ft., as at Zurich, a 12in. main would transmit 133 h.p., and a 24in. main 533 h.p. Mains of this size can be used with such a pressure. With the high pressure of 750lb. per square inch, and at the same velocity, as in the case of the London hydraulic power system, a 6in. main transmits 116 h.p., and a 12in. main, if it could be safely used, would transmit 463 h.p. The horse power is gross horse power, without allowing for loss in the motors.

In neither the high pressure nor the low pressure system is the amount of power which can be transmitted by a single main very great. This involves a definite limitation of hydraulic systems. They are best adapted for driving machines working only a fraction of the 24 hours, or for motors for small industries not requiring a great amount of power.

Loss of Pressure due to Friction in the Mains.—At a velocity of 3ft. per second the loss of pressure per mile of main, due to friction, is about 18lb. per square inch in a 6in. main; about 9lb. per square inch in a 12in. main, and about 4½lb. per square inch in a 24in. main. These losses are insignificant on a high-pressure system, and not very important on a low pressure system, with distances of transmission such as are practically attempted. The losses of energy due to distribution in an hydraulic system, apart from those due to the pumping or motor machines, are so small in most cases that they may be dismissed from consideration without any very serious error.

The following table gives the loss due to friction at a velocity of 3ft. per second per mile of main:

Diameter of main in inches.	Loss due to friction per mile—In feet of head. Clean.	Encrusted.	In lbs. per sq. in. Clean.	Encrusted.
6	35·5	70·9	15·37	30·70
12	16·3	32·5	7·06	14·07
24	7·4	14·8	3·20	6·41

For rough calculations, the loss of pressure per mile may be taken at 107 d lb. per square inch. The percentage loss per mile, reckoned on the working pressure, is as follows:

NEW AND CLEAN PIPES.

Diameter in inches.	For pressure in feet of— 100	250	500	1,000	1,600
6	35·5	14·2	7·1	3·5	2·2
12	16·3	6·6	3·3	1·6	1·0
24	7·4	2·8	1·4	0·7	0·5

With encrusted pipes the percentage loss is double as great. The loss in any case is not very important for working pressures of more than 500ft. of head and distances of transmission likely to be attempted. For small working pressures, or greater velocity in the main the frictional losses become much more important. That is one reason why high working pressures are advantageous in hydraulic systems.

Considerations arising out of the Strength of the Pipes.—In all hydraulic systems at high pressure in this country cast-iron pipes have been used, with a peculiar flanged joint having two bolts. Mr. Ellington's experience in London shows that a main of this kind can be made absolutely tight and free from leakage. The largest mains used are 7½in. in diameter. The working stress in the metal, due to the water pressure, is 2,800lb. per square inch. The mains are usually tested to a water pressure of 2,500lb. per square inch before laying, and to a pressure of 900lb. to 1,600lb. per square inch after laying.

Fig. 20 shows at A the form of joint used by Lord Armstrong, and at B a modification introduced by Mr. Ellington. The joint is made tight by a guttapercha ring. The flanges are placed in a horizontal position in laying. Mr. Ellington found that fractures in the pipes occurred by the breaking off of one of the lugs for the bolts. By placing the lugs a little further back on the pipe the strength was found to be greater. Probably the slight flexibility of the pipe line that this form of joint allows is an important element in its success.

Probably, solid-drawn steel pipes would now be used, if a suitable joint for them could be devised. Such pipes were proposed to be used in a project submitted to the Niagara Commission by MM. Vigreux and Feray. For steel pipes a stress of 15,000lb. per square inch might be allowed; and the use of such pipes would much extend the capabilities of the high pressure hydraulic system. On low-pressure hydraulic systems ordinary socket pipes can be used.

Considerations arising out of the Weight and Cost of the Distributing Mains.—For pipes of equal strength, and at a given limiting velocity of flow, the weight of mains is simply proportional to the horse power transmitted. Hence so far as cost of mains is concerned, the low pressure system is as economical as the high-pressure system. No doubt, however, if all practical exigencies are taken into account the cost of mains is somewhat greater for low pressure than for high pressure systems.

Considerations arising out of the Type of Motors Driven by the Pressure-water.—On high pressure systems the motors used are almost exclusively pressure engines—that is, motors with reciprocating plungers or pistons. Such motors become extravagantly costly for low working pressures. The greater the working pressure, the more conveniently and cheaply is the power produced by motors of this class. Hence the general adoption of pressures of 700lb. to 800lb. per square inch in high pressure systems. The pressure-engine type of motor is extremely convenient for lifting machinery and hydraulic presses, and even for rotative motors of small size. It is not nearly so convenient when a large amount of power is to be developed continuously for driving a factory. For that purpose turbine motors are much better, being cheaper and more easily regulated. It is true that some of the newer types of turbine—such as impulse turbines and Pelton wheels—can be used even at pressures of 800lb. per square inch. But, on the whole, low-pressure reservoir systems are better suited to cases where power has to be developed by turbines.

* Howard Lectures delivered before the Society of Arts.

High Pressure Systems.

*The Hull Hydraulic Power System.** This was the first scheme for distributing power hydraulically to many consumers. The principal main is 6in. in diameter and 1,485 yards in length. The joints were flanged joints, with a guttapercha ring of the kind generally used since. The pumping station is arranged for four 60 h.p. engines, of which two have been erected. Each engine delivers 130 gallons per minute at 700lb. per square inch pressure, corresponding to 63.6 effective horse power. There is an accumulator 18in. in diameter and 20ft. stroke, loaded to 610lb. per square inch. The charges were originally intended to be £52 for one crane per annum, and less for several cranes in one warehouse. The charges are, however, by quantity of water supplied as measured by meter. The minimum charge is £8 per machine per annum. The charge by quantity of water used ranges from £8 per annum for 16,000 gallons, or less, to £200 for 1,200,000 gallons, with special rates for greater quantities. The following short table will give an idea of the way the charges are graduated.

Consumption of water per quarter. Gallons.	Charge per quarter. £ s. d.	Charge per 1,000 galls. supplied. Shillings.
4,000 or under	2 0 0	10.0
9,000 to 10,000	3 10 0	7.0
49,000 to 50,000	12 10 0	5.0
99,000 to 100,000	20 0 0	4.0
199,000 to 200,000	35 0 0	3.5
299,000 to 300,000	50 0 0	3.3

The charge in excess of 300,000 gallons per quarter is 2.5 shillings per 1,000 gallons. For 500,000 gallons per quarter, 2.5 shillings per 1,000 is charged for the whole supply.

The London Hydraulic Power Company.† An Act was obtained in 1871 for supplying hydraulic power in London. The rights conferred by the Act remained dormant until resuscitated by Mr. Ellington in 1882. The present company was constituted in 1884. In 1887 25 miles of pressure main had been laid in London streets, and at the present time there are nearly 60 miles of pressure mains. These extend from the West India Docks and Wapping on the east, to Kensington on the west; from Mint street, south of the river, to Clerkenwell and Old street on the north.

There are three principal pumping stations: one at Falcon Wharf, a short distance east of Blackfriars Bridge (800 i.h.p.); another at Millbank, Westminster (600 i.h.p.); and one at Wapping (1,200 i.h.p.). A fourth station, in the City road, is in course of erection (1,200 i.h.p.). The aggregate power of all the stations, when complete, will be 3,800 i.h.p., of which one third is reckoned as reserve power in case of repair or accident.

At Falcon Wharf and Millbank all the water is taken from the river, but it is filtered before it is pumped into the mains. At Wapping, part is taken from the London Dock, part from a well. After use by consumers it flows into the sewers. The power is available for use night and day all the year round. It is largely used for lifting machinery and for presses and pumps. The company claim that it can be used for electric lighting of particular establishments and for extinguishing fires. For this last purpose Mr. Greathead's injector hydrant or hydraulic intensifier is applied. A small jet of water from the high pressure mains is made to intensify the pressure of a larger jet drawn from the ordinary town mains. A fire stream is so obtained capable of reaching the top of high buildings without employing a fire engine. In 1892 there were 1,696 machines worked by pressure water from the company's high pressure mains, consuming 6,000,000 gallons per week. The quantity of water used by each consumer is measured by a meter on the exhaust pipe of the machines driven. Parkinson's meter is most used. Siemens's turbine meter is used to some extent, but it is inaccurate under the sudden fluctuations of discharge which occur. Kent's positive meter is also used.

At Falcon Wharf there are four sets of compound pumping engines capable of indicating 200 i.h.p. They are vertical, with one high and two low pressure cylinders, and a pump plunger directly connected to each piston. At 200ft. of piston speed per minute each set of engines will deliver 240 gallons per minute, at 750lb. per square inch pressure, into the accumulator. This corresponds to 120 effective horse power. A nine hours' trial of one set of engines was made in 1887, the engine running at constant speed and the coal used being seaborne small coal. The boilers are provided with an economiser.

Trial of Hydraulic Pumping Engines.

Total indicated horse-power	178.5
Piston speed, feet per minute	221.4
Steam pressure, pounds per square inch	82.5
Evaporation (from and at 212deg.) per pound of fuel, pounds	10.59
Feed water per indicated horse power hour, pounds	19.79
Coal per indicated horse power hour, pounds	2.19
Accumulator pressure pounds per square inch	750
Effective horse power, calculated from water pumped, allowing 5 per cent. slip	139
Mechanical efficiency of engine	0.78
Water pumped per minute (gallons)	205.7

The engines consume, in ordinary work, 2.93lb. of coal per indicated horse power, which is greater than the result given above, in consequence of the fluctuation of speed.

There are two accumulators at Falcon Wharf, with rams 20in. in diameter and 23ft. stroke. Each accumulator has a capacity of storage equal to 2.4 horse power hours. The filters are Perrett filters, constructed by the Pulsometer Company. The filtering material is compressed sponge. It is cleansed every four to six hours by reversing the direction of flow, and by alternately compressing and releasing the pressure on the sponge.

The pumping station at Wapping is a more recently constructed and larger station than that at Falcon Wharf. The water pumped is obtained partly from a well sunk into a gravel bed, partly from the London Dock. The pumping from the well into a tank over the boiler house is effected by low lift pumps worked hydraulically by the pressure water. From this tank it passes through "Torrent" filters constructed by the Pulsometer Company to underground reservoirs. From this it is lifted by the condenser circulating pumps to another tank above the boiler house, whence it is pumped into the mains. The reservoir capacity is 800,000 gallons. The engine house contains six sets of vertical inverted triple expansion engines with cylinders 15in., 22in., and 36in. diameter, and 24in. stroke. Each piston drives a single-acting plunger pump, with ram 5in. diameter, direct from the cross head. The working steam pressure is 150lb. per square inch, and the hydraulic pressure 800lb. per square inch. Each set of engines will deliver 300 gallons of water per minute at a piston speed of 250ft. per minute. All the cylinders are jacketed.

In a test trial the engines are stated to have worked with 14.1lb. of steam, and 1.27lb. of Welsh coal per indicated horse-power hour. The water passes from the pumps to two accumulators with rams 20in. diameter and 23ft. stroke. One of the accumulators is loaded to a slightly heavier pressure than the other, so that one accumulator rises a little in advance of the other. The more heavily loaded accumulator automatically shuts off steam when at the top of its stroke. A good description of these works will be found in *Engineering* for January 20, 1893.

Charges for Pressure-water for Power Purposes.—The London Hydraulic Company make a minimum charge of £1. 5s. per quarter per machine. For consumers using more than 3,000 gallons per quarter, there are graduated charges, of which the following short table gives a sample.

Gallons used per quarter.	Charge. £ s. d.	Cost of pressure water per 1,000 gallons. Shillings.
3,000, or under	1 5 0	8.3
10,000	3 10 0	7.0
50,000	12 10 0	5.0
100,000	20 0 0	4.0
200,000	31 5 0	3.1
300,000	42 10 0	2.8

For an excess over 300,000 gallons per quarter is charged at 2s. per 1,000 gallons. Consumers using more than 500,000 gallons per quarter are charged 2s. per 1,000 gallons all round. Rates are further reduced for still larger quantities, and the minimum rate is 1.5s. per 1,000 gallons.

With these charges the cost of power for the kind of work for which an hydraulic system is best suited is small. Thus it is often less than one farthing per ton lifted 50ft. On the other hand, it is necessary for the purpose of this treatise to consider the cost of power distributed by different methods on some common basis. It is almost unavoidable to take the cost of power exerted continuously through the working day. If the cost of power supplied by the Hydraulic Power Company is reckoned for machines working 3,000 hours per year, then the cost is larger than that of power obtained in other ways. The comparison of the cost so reckoned is instructive, although it may be in fairness pointed out that Mr. Ellington, in his paper, stated that he had never advocated the supply of power for continuous driving engines to any large extent.

To obtain one effective horse-power during 3,000 hours per annum, allowing an efficiency of 80 per cent. in the motor, 437,500 gallons of water are required. Hence, a consumer taking 50,000 gallons per quarter would get the equivalent of 0.457 effective horse power for 3,000 hours, and would pay for it at the rate of **£109 per horse-power per annum.** A consumer taking **300,000** gallons per quarter would get the equivalent of 2.743 effective horse power for 3,000 hours, and would pay at the rate of £62 per effective horse power per annum. A consumer taking 500,000 gallons per quarter would get the equivalent of 4.573 effective horse-power for 3,000 hours, and would pay at the rate of £43. 15s. per effective horse power per annum. It must be remembered that this is the cost for pressure water only, and does not include meter rent or interest on the cost of the motors.

The Liverpool Hydraulic Supply System.—In Liverpool, pressure-water from the town mains was used for working hydraulic cranes as early as 1847. From an interesting paper by Mr. Joseph Parry* it appears that the use of hydraulic power in this way made very slow progress. In 1877 the number of hydraulic machines supplied from the town mains was 89. At the present time there are 162 machines worked by water from the town mains, consuming 125,600,000 gallons per annum. Taking the mean pressure at 70lb. per square inch, this is equivalent to 82,710 effective horse power hours, or to 27 effective horse power for 3,000 hours in the year—a rather insignificant amount. The average charge for working a goods hoist is £13 per hoist per annum, or only 10d. per hoist per day—a small cost for the convenience afforded. The charge for water is 7d. per 1,000 gallons. At this rate the charge is equivalent to £120 per effective horse power per year of 3,000

* See Robinson, *Proceedings* Institution of Civil Engineers, vol. xlix.

† The account of the London hydraulic system is taken partly from a paper by Mr. E. B. Ellington, *Proceedings* Institution Civil Engineers, vol. xciv., partly from the reports of the company.

* "The Supply of Power by Pressure from the Public Mains." *Proceedings* Institution of Mechanical Engineers.

hours. Experiments on the quantity of water used by some hoists showed the cost to amount to from 6d to 10d. per ton lifted 50ft.

There is also in Liverpool a high pressure system, which is to be extended. Experiments with some hoists worked on this system showed the cost to be from 1½d. to 2½d. per ton lifted 50ft. Mr. Parry comes to the conclusion that hoists worked from the town mains cost more than those on the high pressure system when the charge for water on the high-pressure system does not exceed 5s. per 1,000 gallons.

The Birmingham Hydraulic Power System.—In Birmingham, as in Liverpool, water has been supplied from the town mains to work lifts. In 1888 there were 61 lifts and hoists thus worked, using 80,000 gallons per day, and yielding to the Water Committee of the Corporation about £1,000 a year. Since that time a high pressure system has been carried out, which has the peculiarities that it belongs to the Corporation, and that the pumping is done by gas engines.*

At the pumping station there are three sets of triple hydraulic pumps, working to a pressure of 730lb. per square inch. These are driven by three Otto gas-engines, nominally 12 h.p., 20 h.p., and 20 h.p., but capable of developing an aggregate of about 100 h.p. Ordinary lighting gas is used. The pumps deliver into two 6in. mains. There are two accumulators, with 20in. rams and 20ft. stroke. A small Brotherhood engine, worked by the pressure-water, is used in starting the gas engines.

Manchester Hydraulic Power Supply.—At Manchester a combined scheme for supplying electricity and high pressure water is being carried out. A pressure of 1,000lb. per square inch in the hydraulic system is to be used. It is hoped that there will be economy in working the electricity and pressure-water supply from the same station.

LOW PRESSURE HYDRAULIC SYSTEMS.

The Zurich Works.—The Zurich installation is a complex and very interesting one.† It was the earliest example in Switzerland of the application of hydraulic power, partly to pump a supply of potable water, partly to furnish motive power from the same central station. It has grown gradually, and of late has been greatly extended. It comprises machinery driven by turbines for furnishing (*a*) a water supply to the town of Zurich; (*b*) a supply of motive power transmitted by wire rope; (*c*) a supply of motive power transmitted by comparatively low pressure water from the town mains; (*d*) a supply of motive power transmitted hydraulically from a special reservoir at comparatively high pressure; (*e*) an electric central station also driven by water power.

When the works were first established the water supply of Zurich was obtained from a filter in the bed of the River Limmat, near its exit from the lake. This water was pumped by turbines erected a little further down stream. There being surplus water power, a telodynamic transmission was erected, and part of the motive power was distributed to factories along the river side. In 1884 the quality of the water was found to be inferior. After extensive investigations, it was decided to obtain a new supply of potable water from an intake in the lake, and to use the old water supply for motive power purposes only.

The fall available in the Limmat at the pumping station and the available volume of flow are as follows:

	Fall.	Volume of water flowing in the river	Gross water H.P.
	Feet.	c. ft. per sec.	H.P.
High-water level in summer	4.92	2,295	1,300
Mean " " "	8.20	1,660	1,570
Low " " winter	10.50	1,059	1,280

The effective power delivered by the turbines in the river is as follows:

	H.P.
For pumping filtered potable water	237
Supplying motive power by pressure water	128
Driving the wire rope transmission	227
Supplying hydraulic motive power for electric lighting station	444
Total	1,036

There are two reserve steam engines of 300 i h.p. each, to provide for a deficiency of water power.

At the pumping station there are eight pressure (Jonval) turbines, working up to from 96 h.p. to 100 h.p., according to the state of the river. There are also two newer turbines of about 175 h.p. each. The turbines have vertical shafts, and each pair drives, by bevel wheels, a common horizontal shaft, which runs at 50 revolutions per minute in the case of the earlier turbines, and at 66 revolutions per minute in the case of the two last erected. From these shafts a horizontal main shaft, 328ft. in length, and running at 100 revolutions per minute, is drawn. To this main shaft any of the pumps may be coupled. The earlier turbines cost, with gearing, about £12 per horse-power, the two larger turbines about £7 per horse-power. There are at present in operation seven sets of horizontal double-acting Girard pumps. The total pumping capacity is 8,143,000 gallons per day. The water for driving the turbines is obtained by a weir in the Limmat which deviates the water into a canal formed by a longitudinal embankment in the river. Sluices divide the head race channel from a tail race channel formed in a similar way. The pumps supply the following reservoirs:

	Height above pumps.	Capacity in c. ft. — Present.	Capacity in c. ft. — To be increased to.
Low level	164	205,000	–
Intermediate level	300	68,500	141,000
High level	485	10,600	21,190
Reservoir for high pressure power-water	528	353,170	529,000

From the town mains water is supplied to work 180 small motors. The total power thus supplied is about 187 h.p., and its cost is about 4.4d. per horse power hour. The principal supply of power, apart from that distributed by wire rope, is obtained from pressure water obtained from the old Limmat filter bed, and pumped to the special high level reservoir. This water is pumped chiefly during the night. The reservoir is about 6,000ft. from the pumping station, and is supplied by an 18in. main. The effective pressure at the motors is about 475ft., and the distributing mains have an aggregate length of 15,000ft. The charge for this pressure water for power purposes varies from 0.6 pence per horse power hour, when at least 50,000 horse power hours are taken in the year, to 1.25 pence per horse-power hour, when less than 20,000 horse power hours are taken in the year. For 3,000 working hours in the year the charge is from £7. 10s. to £16 per horse-power per annum. The water supplied in this way now amounts to 42,380,000 cubic feet per annum, yielding altogether about 900,000 horse power hours. The total receipts are £1,200 per annum, or 1.08d. per 1,000 gallons.

Besides this supply of pressure water to various consumers, the electric station is ordinarily to be driven by pressure water from the same high level reservoir. For this purpose two impulse turbines of 300 h.p. each have been erected for driving dynamos, and two smaller turbines of 30 h.p. driving exciting dynamos. Alternatively, if the supply of pressure water fails, the dynamos can be driven by the river turbines or by the reserve steam engines.

The Hydraulic Works and System of Hydraulic Power Supply at Geneva. There is now in operation at Geneva one of the most remarkable hydraulic power stations in the world. The water of the River Rhone, near the point where it flows out of Lake Leman, is employed to drive a number of large low pressure turbines, giving a total of 4,500 effective horse-power. These turbines pump pure water obtained from the lake into two systems of mains. The older of these termed the low-pressure system, the pressure at the pumps being 160ft. to 200ft., is an extension of a previously existing system of mains used for supplying potable water to the town of Geneva. Although some of the water pumped into this system is used for power purposes, it is chiefly intended to supply water for domestic and municipal purposes. The second system of mains, termed the high pressure system, the pressure at the pumps being 460ft., supplies potable water to some districts not reached by the low pressure system, but it is specially intended to afford a supply of water for motive power purposes to the entire area of the town. The demand for water, both on the low and high pressure system, is a fluctuating demand, large during the day, and very small during the night. Hence, if the turbines in the Rhone were employed solely in pumping into the mains, they would not be continuously working, and a large part of the water power of the Rhone would be wasted. To meet this difficulty, an important storage reservoir has been constructed at Bessinges, about four kilometres from Geneva. The turbines pump water up to this reservoir at night, and at times when the demand for power for other purposes is insufficient to keep them fully employed. The energy derived from water flowing back from the Bessinges reservoir through the high-pressure system represents parts of the water power of the Rhone which would necessarily have been wasted if this means of storage had not been provided.

The works at Geneva have been gradually developed under special local conditions. In spite of natural and political isolation, manufacturing industries have for centuries flourished at Geneva. That they did so is partly owing to the fact that cheap water power could be obtained by simple forms of waterwheel placed in the ample and rapid Rhone flowing past the town. An industrial quarter gathered along the banks of the river, and factories were built even in the stream itself. As the population increased a water supply was required. The small aqueducts of spring water became insufficient, and further recourse was had to the motive power of the Rhone. From the beginning of the eighteenth century waterwheels placed in the Rhone pumped a water supply into the town. Then arose antagonism to the utilisation of the motive power of the Rhone which, for two centuries hindered the progress of industrial enterprise at Geneva, and threatened at times to destroy the existing industries. The properties of riparian owners on the shores of Lake Leman were from time to time injured by the rising of the lake level. It was not unnatural that the landowners should attribute the disastrous inundations from which they suffered to the obstacles created at the outlet of the lake—that is, to the bridges and buildings, and especially the factories and waterwheels in Geneva. Complaints were addressed by the Canton Vaud to the Federal Government at Berne of damage caused by the works at Geneva. Then arose a question of arrangements necessary to regulate the lake level, and to facilitate in time of flood the discharge of the water. From 1875 the project of utilising the motive power of the Rhone took a new magnitude and importance from the combination with it of plans for regulating the level of Lake Leman, and so ending a long and bitter controversy.

Another local circumstance had great influence in determining

* See *Engineering*, February 12, 1892.

† See Preller on "The Zurich Water Supply Power and Electric Works." *Proceedings* Institution Civil Engineers, vol. cxi.

the ultimate form of the project for the utilisation of the motive power of the Rhone. In 1871, Colonel Turrettini,* the engineer under whose direction the present works have been constructed, had applied to the Town Council of Geneva to place small pressure engines on the mains of the then existing low pressure water supply. The plan of obtaining motive power in this way proved so successful and convenient that, in 1880 there were 111 motors at work, using 34,000,000 cubic feet of water annually, and paying a yearly rental for power water of £2,000. The cost of the power at that time to consumers was at the rate of £36 to £48 per horse-power per year of 3,000 working hours.

In 1878 a private firm asked the concession of a monopoly of the motive power of the Rhone, at Geneva, on condition of carrying out works necessary for facilitating the discharge from the lake, and regulating the lake level. A similar offer was made in 1881. But there grew up a feeling that such works should be carried out by and for the profit of the town itself. Finally, after many studies the contract was given by the Municipality in 1883 to M. Chappuis to construct under their direction the present works.

These works have cost, altogether, £283,000. Of this sum, a fraction has been paid by owners of land on the shores of the lake and part has been expended in constructing new sewers required in consequence of the alterations of river level. Deducting these items the cost of utilising the motive power of the Rhone has already amounted to nearly £200,000.

The scheme included the clearing away of all obstacles to the free flow of the river, and the division of the river, by a longitudinal embankment, into two portions, one forming a head race to the turbines, Fig. 21, the other—which was straightened and deepened—forming an outlet for the surplus water from the lake. Between the two divisions of the river bed are movable sluices which keep up the water in the head race channel, or discharge surplus water into the tail race channel, according to the condition of the lake. The scheme also included a complete reconstruction of the old pumping system for the low pressure water supply, the creation of the new system of high-pressure water supply, and the provision of motive power by hydraulic transmission to the industries of the town.

The Low Pressure River Turbines.—The turbine and pump house is placed at the end, Fig. 21, of the left-hand channel or head-race. The turbines are of 210 h.p. each, and 14 groups of turbines and pumps have been erected. Four more groups, of somewhat greater power, are expected to be erected within the next five years. The turbines are Jonval pressure turbines, constructed by Messrs. Escher, Wyss, and Co., of Zurich. They have vertical shafts and each turbine drives from a crank two horizontal double acting Girard pumps, placed at right angles.

The head at the turbines varies from 5·5ft., when the river is in flood, to 12·14ft. when the volume of flow is smallest. With most forms of turbine this would involve a considerable variation of the normal speed, or speed of greatest efficiency. The turbines are skilfully arranged to meet this variation of head. The turbine wheel and its corresponding system of guide passages is arranged in three concentric rings. When the fall is great and the quantity of water used is smallest, the outer ring only is open, and the water acts at a large radius. As the fall diminishes, the second ring is opened, and the mean radius, at which the water acts, is smaller. In the lowest condition of the fall, when most water must be used all three rings are open, and the mean radius at which the water acts is smaller still. The number of rotations of the turbine depends entirely on the velocity due to the head and inversely on the radius at which the water enters. Hence, as the radius diminishes as the head diminishes, a fairly constant speed of rotation is obtained. The adjustment is such that, with the highest fall, the normal speed is 27 revolutions per minute, and with the lowest fall, 24 revolutions per minute, a variation not practically serious in working pumps.

The fixed distributor over the turbine wheel is 13·78ft. in external diameter and 5·74ft. in internal diameter. It is divided into three rings, having 52 guide passages in the outer ring, 48 in the middle ring, and 40 in the inner ring. The external ring has no regulating sluices, regulation being effected, when that ring only is open, by the sluices in the head race. The other rings are arranged so that over one semicircle the orifices open vertically on an annular plane surface, and over the other semicircle they open horizontally on a cylindrical surface. Each ring of passages has two regulating surfaces—one a semicircle annular plate for the orifices opening vertically; one a semi cylinder for the openings which are horizontal. Each sluice can be fully opened without interfering with the openings corresponding to the other. The sluices are worked by gearing. The turbine wheel is of cast iron, in two halves. It has wheel passages corresponding to those in the distributor.

The vertical support of each turbine consists of a fixed wrought-iron pillar, carrying at its top a steel step for the pivot and a steel revolving hollow shaft hanging from the pivot at the top. The pivot is 6in. diameter. A crank at the top of the shaft drives two Girard double-acting pumps placed at right angles from a single crank pin. The Girard pump consists virtually of two plunger pumps placed end to end, the advantage being that the stuffing boxes for the plungers are accessible and there is no internal packing. The two pumps discharge into a single air vessel placed between them. The diameter of the plungers of the low pressure pumps is 1·41ft., that of the high pressure pumps 1·08ft. and 0·85ft. The stroke is 3·61ft., and the mean velocity 188ft. per minute. The valves are ring valves with leather faces. The high pressure pumps supply mains of 20in. diameter, and of 24in. and 16in. in the other. The low-pressure pumps supply two mains of 20in. diameter.

(To be continued.)

* "Utilisation des forces motrices du Rhone et régularisation du lac Leman." Th. Turrettini, Ingenieur Conseiller Administratif delégue aux travaux. Geneva, 1890. This admirably illustrated memoir fully describes the origin, progress, and details of all the works at Geneva.

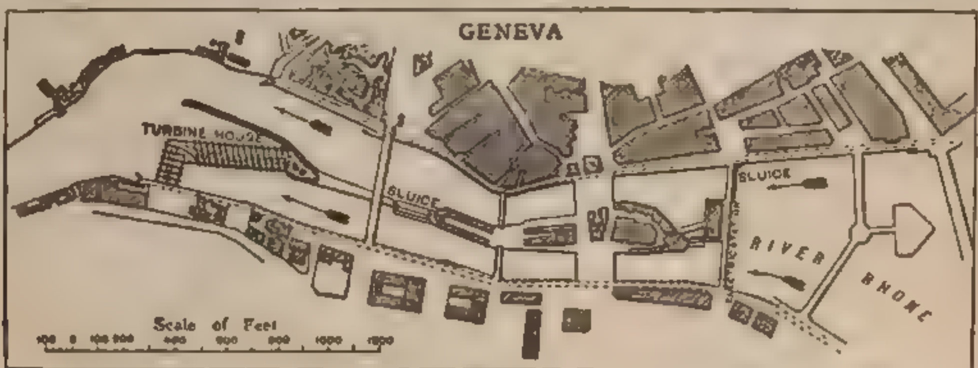


FIG. 21.

LEGAL INTELLIGENCE.

POLLARD v. RUST.

In the Queen's Bench Division on Monday, before Mr. Justice Cave, sitting without a jury, the case of Pollard v. Rust came on for hearing. Mr. Edward Bray was counsel for the plaintiff, and Mr. William Willis represented the defendant.

Mr. Bray said this was an action to recover £1,333. 6s. 8d., two thirds of the sum of £2,000 bonus, which the defendant was alleged to have received from Mr. Charles Langdon Davies, an electrician. The plaintiff's case was that Mr. Rust promised to pay him two thirds of the bonus if he would guarantee the repayment of certain advances which Mr. Rust had made to Mr. Langdon Davies. It was alleged that the £2,000 was received by Mr. Rust, and therefore that plaintiff was entitled to two thirds of that sum. The defence was a denial of plaintiff's allegation, and as a set off that there was a release or discharge from the claim in July, 1887. The plaintiff was a well known barrister, and the defendant, Mr. Arthur Rust, was a merchant, carrying on business at Leicester. Mr. Langdon Davies was interested in certain patents, the object of which was to utilise telegraph wires for the purpose of telephonic work at the same time that they were being used for telegraphy. He had made some arrangements with a gentleman in Belgium with reference to taking over certain patents of that gentleman for the purpose. He wanted money in order to purchase these patents, and to bring out a company. Accordingly he advertised in December, 1883, saying he desired to obtain the use of £10,000—£2,000 at once, £2,000 more later on, and in certain events £6,000 more. Mr. Rust whom Mr. Davies had not known before, wrote to him in relation to the advertisement, and in the correspondence Mr. Rust said he desired to have a guarantee for the repayment of the £2,000 and possibly for the repayment of the further sums. Mr. Pollard, who was a friend of Mr. Langdon-Davies, was mentioned to Mr. Rust. In January, 1884, the parties met at Mr. Pollard's chambers, and Mr. Pollard was willing to guarantee the repayment of £1,500 without any consideration from Mr. Rust, but Mr. Rust wanted something further. He desired, if he advanced the whole £10,000, that Mr. Pollard should be responsible to the extent of £1,500 until the whole £10,000 was repaid. He offered to give Mr. Pollard a portion of his bonus if he would agree to that. Mr. Pollard wrote that in consideration of Rust paying him £750 of his bonus he would do that. Later on Mr. Rust advanced Mr. Langdon Davies another £500, making £2,000 in all, and Mr. Pollard became responsible for the £2,000. Then it turned out that the Belgian patents would not be of sufficient value, but Mr. Langdon Davies had meanwhile made an invention of his own, and a correspondence arose with Mr. Rust with reference to further advances, in carrying out that patent. In

April, 1884, Mr. Pollard expressed his willingness to continue the guarantee of the £2,000, and agreements were drawn up upon which this question depended. The agreement between Langdon Davies and Rust recited that the latter should advance a further £2,000, making £4,000 in all, and keep ready a further sum of £6,000. In case the £10,000 was advanced, it was provided that, in addition to the repayment of that sum, Mr. Rust should have a bonus of £10,000. If a sale should be effected without the £6,000 having been advanced, then Mr Rust was to have £4,000 for keeping the money idle, and if the £6,000 was not advanced, and the company was not formed, the £4 000 was to be repaid with a bonus of £2,000, these sums being paid by instalments. By an agreement between Mr. Rust and Mr Pollard, it was provided that the former should pay to the latter two-thirds of the bonus he received in respect of the first £2,000 advanced to Davies as soon as he received such bonus, Mr. Pollard's guarantee of the £2,000 continuing until all the principal-money had been repaid by Mr. Davies. Later, in July, 1887, an arrangement was come to between Rust and Davies by which the latter sold the former half his patent rights for £5,000, and a discharge of his liabilities to Rust. The result of that, according to the plaintiff's case, was that Rust got his £2 000 bonus, if not a larger sum, and, that being so, Mr Pollard was, under his agreement, entitled to two-thirds of that £2,000.

The **Plaintiff**, in the course of his examination, stated that a company was formed, called the Phonopore Syndicate, to which Rust and Davies were joint vendors of £42,000 in cash and shares. He admitted that he was not entitled to any bonus on the first agreement, but said he was entitled to one on the second. The defendant had never served him with a month's notice that the guarantee was to be continued, as provided for in the contract. He relied on the last contract with him in May, and unless what took place in July between Davies and Rust amounted to the receipt by the latter of a bonus or its abandonment, if good consideration, he had no case.

Mr. Davies also gave evidence in plaintiff's favour.

Mr. Wills, who previously called Mr. Rust, and asked him a few questions as to some of the details of the case, contended in the first place that there was no liability on the part of defendant to the plaintiff at all, as no bonus had been received. Even if there was any liability, it only extended to £666, or two-thirds of £1,000.

The learned **Judge** gave judgment for the plaintiff for £666. 13s. 4d.

THOMPSON v. COWLES SYNDICATE, LIMITED.

In the Queen's Bench Division, on Wednesday, Mr. Thompson, an electrical engineer, of Victoria street, London, sued the Cowles Syndicate, Limited, of Stoke-on-Trent, aluminium manufacturers, to recover £293 odd, for carbon rods supplied. The defendants alleged that the carbons were soft and of inferior quality, and counterclaimed £400 damages. Mr. Moulton, Q.C., and Mr. Tindal Atkinson were for the plaintiff; and Mr. Bousfield, Q.C., and Mr. Bray for defendants.

Mr. Tindal Atkinson, who opened the plaintiff's case, said the real dispute was as to the terms on which the carbon rods were supplied—that is, whether the contract was for the supply of a certain quality in respect to hardness and density or whether they were supplied by sample. The plaintiff's allegation was that the carbons were supplied to sample. The plaintiff was then called, and stated that a number of samples were sent to the defendants to experiment upon, and when they had selected the best for their purpose the carbon rods were sent on to the defendants direct from the manufacturer, M. Berne, of Paris, for whom witness was merely acting as agent in this matter. Witness did not himself see the carbon rods which were delivered, though his information was that they were rods 3ft. long and 3in diameter. In cross-examination, witness said he believed the defendants were the only manufacturers in England who used the electric process for the smelting of aluminium. He denied that an inferior carbon was supplied. A soft carbon was not necessarily inferior to hard carbon; it depended altogether upon the process in which it was used; in some cases the soft carbon would be best. It was in order that the defendants might select the best for their purpose that the samples were sent.

Robert Francis Hayward, formerly manager of the works department of Messrs. Crompton and Co., and who was a year in the employment of the defendants, from 1889 and 1890, said he considered the carbons supplied suitable for the Cowles process.

Mr. Bousfield objected that the Cowles process was not the process used by the defendants now, but Swig's process, which the plaintiff knew very well. The evident was therefore, he submitted, irrelevant.

At this point the further hearing of the case was adjourned till to-day.

COMPANIES' MEETINGS.

CHATHAM ELECTRIC LIGHTING COMPANY, LIMITED.

A meeting of the shareholders in this Company was held at the works, Whittaker street, Chatham, on Wednesday of last week, to consider the proposal of the Directors for the issue of debenture shares to the value of £12,000.

Mr H. Jasper, chairman of the Directors, who presided, said: The chief object of this meeting is to enable me to put before the shareholders the general position of the Company, and the reasons why the Directors deem it necessary that there should be at once an issue of debentures to the extent of £12,000. A considerable sum will be required in the immediate future for the compulsory extension of mains, and for certain necessary extensions of premises; also for the paying off the bank loan and other creditors. We find it will be an easy matter to float the Company's debenture bonds in London if issued at the ordinary rate of interest for such stock. Personally, I think it will be an utter waste of time to issue these debentures at less than £6 per cent., redeemable in 12 years at £105. If they are placed before the public in this way, our substantial works and plant and our present profitable working will form sufficient guarantee and be satisfactory to the most cautious of investors. At this price I shall be willing to take up a considerable portion myself. But I am not anxious in the least degree to do this because it has always been my desire to make this a consumers' company. It was for this reason that I offered the whole of my shares obtained on the contracts of the value of £18 630 at a discount of £33 per cent., not only to the shareholders, but also to the general public. I did this voluntarily, when I found that several of the shareholders had expressed an opinion that my having taken these shares at such a discount was too highly favourable to myself and was very sharp practice, notwithstanding that I had offered the same terms again and again to those whom I thought would have advanced the money absolutely necessary to be found at that time to save our provisional order. Had I then have used my powers for sharp practice I should hold to-day practically all the shares in the Company, seeing that I could at any time have "beared" the market and bought at my own price. This, although often done, would have constituted a proceeding which might be called sharp practice. I threw out this offer more as a challenge to test if any man had the courage of his professed convictions. Not that I at any time desired to part with a single share, nor have I any such desire now, knowing too well the value of the undertaking, but for the fact previously stated that I desired, and still do desire, that this should be a consumers' company. In fact, instead of selling, I have bought out one of the largest shareholders. But to carry out my original object, I am still prepared, for a limited period, to sell a few shares at £25 per cent. premium—but only a few—because I see clearly the great coming advantages of this electric generation. Among these advantages are the treatment of sewage, power, and the fact that the monopoly gives an unlimited dividend—there being no maximum as in the case of gas and water undertakings. I admit that we cannot make such profitable returns as corporations carrying on similar work, because they can with the utmost facility always obtain money at 3 per cent., as may be seen in the case of Grimsby only last week. I should like to point out another advantage there is in corporations carrying on the business of electrical supply: it is that all the ratepayers being partners in the concern would on that account become customers, knowing that they would get a great part of the cost returned in the reduction of their rates. Again adverting to the necessity for the debenture issue, I may say the subscribed capital of the Company is, at the present time, £28,600, of which I hold no less than £25,600, in addition to loans advanced by me to the Company amounting to about £1,400. I am likewise responsible to the bank, in respect of its loan of £3,000, to a further extent of £2,700. I have accepted this responsibility, although our bank, like all the leading banks, will not grant the same privileges as in the case of gas or water stock—viz., advance upon it. But seeing what has taken place at Grimsby and other places, I feel assured that the time is not far distant when bank directors will see it is to their interests to place electric light and power stock on the same footing on gas and water.

A long discussion on matters of detail ensued, **Mr. Leavey** asking, if these debenture shares were issued as explained by the Chairman, what chance would the original shareholders have of ever getting anything out of the Company?

The **Chairman** replied that the Company had now the plant, and this would be complete within a few days, and now they wanted to cover districts with mains which were not already covered. With these debenture shares they would be able to increase their business, and he felt sure that in that event the shareholders would reap an advantage for which they incurred no responsibility whatever.

Mr. Wingent proposed that the amount of debentures at present issued should be sufficient only to cover bank loan (for which he was partly responsible), together with the amount necessary for present extensions of mains; but the Chairman then offering to become responsible for the whole loan, Mr. Wingent ultimately proposed that the meeting sanction the issue of £12,000 in debenture shares on the best terms that could be got, but only £4,000 was to be taken up before another meeting of the shareholders was called.

Mr. Leavey seconded, and the Directors having accepted the motion, it was carried unanimously.

West India and Panama Telegraph Company.—The report of this Company for the half-year ended June 30 states that the amount to credit of revenue is £46 687, against £44,148, the expenses amounting to £24,794, against £28,589. The balance, with £1 430 brought forward, makes a total of £23,323. Of this sum the directors have placed £3,000 to reserve, leaving an available balance of £20,323, out of which it is proposed to pay a dividend on the first preference shares of 6s., one on the second preference shares of 6s., and one on the ordinary shares of 1s. per share, tax free, £4,137 being carried over. The traffic receipts for the two weeks ended October 31 were £120 more than for the corresponding period.

BUSINESS NOTES.

Anglesey. – A telegraph office has been opened at Moelfre, Anglesey.

Bournemouth. – The Corporation intend to apply for a provisional order.

Penrith. – The Board of Health intend to promote a provisional order for electric lighting.

Great Northern Telegraph Company. – The receipts for the month of October amounted to £23,200.

Portsea. – The Board of Guardians intend to have their offices in St. Michael's-road lighted electrically.

Tunbridge Wells. – The Corporation have decided to spend £13,000 in introducing electric light in the chief streets.

Dewsbury. – Tenders are invited by the Corporation by 17th inst. for work in the erection of an electric light station.

Lynton. – Mr. Benn notifies that he is applying for a provisional order in connection with the existing electric lighting works.

Norwich. – The authorities propose to light by electricity the reading room of the Norfolk and Norwich Library at a cost of £100.

Cuba Submarine Telegraph Company. – The receipts for the month of October were £539 less than for the corresponding period.

Direct Spanish Telegraph Company. – The receipts for the month of October were £186 less than for the corresponding period.

Moss Side. – The Collier Marr Telephone and Electrical Manufacturing Company, Limited, of Manchester, have applied for a license for the supply of electrical energy.

Ealing. – A Local Government Board enquiry has been held in regard to the application by the Urban Authority for permission to borrow £25,000 for electric lighting purposes.

East Ham. – The Local Board have constructed an infectious diseases hospital at the sewage works, and have lighted it by electricity, the motive power being supplied by the pumps.

Pontardawe. – An application has been sent to the Board of Trade by Messrs. W. Gilbertson and Co., Limited, of Cardiff, for a license to light certain streets in Pontardawe by electricity.

Newcastle. – The City Lighting Committee of the Corporation have decided that an electric light of 1,500 c.p. shall be placed at the top of Pilgrim-street and another lamp in Newgate street.

Stafford. – The tender of Messrs. Rooper and Tozer for providing and fixing electric light conductors in the new County Council buildings – viz., £460 – has been accepted, this being the lowest offer.

Clay Cross. – At a meeting last week of the Local Board, Mr. Foster raised the question again of the want of more street lamps, and it was mentioned by several members that it was advisable to introduce the electric light.

Redditch. – A deputation of the Local Board, consisting of Messrs. T. W. Baylis, W. Woodfield, W. Gibbs, and T. Evans, has been appointed to visit Rugby, and report upon the system of electric lighting adopted there.

Chiswick. – A letter was read from Mr. Stuart at a meeting of the Local Board last week, as to the maintenance of the electric fire alarms, in which he complained of his cheque being kept back. Instructions were given for the amount to be paid.

Shiplighting. – On Saturday the s.s. "Chickahominy" went on her trial trip off the Hartlepool coast. The vessel is fitted throughout with a complete arrangement of electric lighting, supplied by Messrs. Clarke, Chapman, and Co., of Gateshead.

Blyth. – Councillor Humphreys called attention, at a meeting of the Council last week, to the prompt action of the town clerk in connection with the failure of Mr. J. T. Chappell to execute the work for the extension of the Corporation electricity generating station.

Peterborough. – The following streets have been scheduled in the proposed electric lighting provisional order: Bridge-street, Narrow street, Market place, Long-causeway, Midgate, Westgate from Long causeway to Boroughbury, Church-street and part of Cowgate.

Oystermouth. – The Oystermouth Local Board of Health have requested their engineer, Mr. John Stansfield Brun, C.E., of Mumbles, to prepare and submit to them, at his earliest convenience, a report upon the installation of the district with the electric light.

Western and Brazilian Telegraph Company. – For the six months ended June last the accounts show an available balance, after providing for debenture interest, of £19,679. From this sum £12,000 is to be placed to the reserve fund, leaving £7,679 to be carried forward.

City and South London Railway Company. – The receipts for the week ending November 5 were £871, against £891 for the same period last year, or a decrease of £20. The total receipts for the second half year of 1893 show an increase of £237 over those for the corresponding period of 1892.

Douglas and Laxey Electric Tramway. – Tenders are invited for the extension to Laxey of the existing line from Douglas to Groudle Glen. The work comprises a roadway, and the laying of two lines of 3ft. gauge. Further particulars will be given in *the Contract Journal* next Wednesday.

Blackburn. – The temporary station will be completed in February. The plant will comprise four dynamos, two of 120 kilowatts and two of 45 kilowatts, two batteries of accumulators, each of 60 cells, capable of supplying 300 amperes for $3\frac{1}{2}$ hours. It is intended to charge $6\frac{1}{2}$d. per unit for current.

Brush Company's Shares. – In their November report Messrs. Stanley Geo. Pittield and Co., 4, St. Mary axe, E.C., state that both the ordinary and preference shares of this Company remain very hard at $2\frac{7}{8}$ $3\frac{1}{8}$ and $2\frac{1}{8}$ $2\frac{3}{8}$ respectively, that they have repeatedly advised their purchase, and that they see no reason to alter their opinion.

Belfast. – The report of the Gas Committee of the Corporation presented last week mentioned that the committee had received from Prof. Kennedy several of the principal specifications for the electric lighting plant, and that when the remainder came to hand they proposed to advertise for contractors to tender for the supply of what is required.

Llanelly. – The members of the Local Board, accompanied by the town clerk (Mr. John Jenkins) and the surveyor (Mr. Watkeys), journeyed the other day to Pontypool for the purpose of inspecting the lighting of Pontypool by electricity, and eventually to consider the advisability of introducing the same method of public lighting in Llanelly.

Mine Lighting. – The inauguration of the electric light at Stanton Pit has just taken place. The work has been carried out by Messrs. Verity and Sons, of Birmingham and London. The whole of the screens and loading belts are lighted. This is the first work under the direction of their new agent, Mr. Henry Lee, High street, Burton.

New Cable Offices. – The Eastern Telegraph Company, Limited, have opened a branch telegraph office in the Foreign Auction Hall, Covent Garden Market, for the exchange of telegrams with Spain and the Azores and the company's general system of submarine telegraphs. The Direct Spanish Telegraph Company have opened a branch in the same building.

Dewsbury. – It is intended to instal the electric light at the Self Help Stores. Arrangements are already well in hand for lighting the central premises by electricity. Negotiations are being made with one or two companies with a view to a speedy adoption of the new light, and the installation, it is expected, will be put in during the next few weeks.

Sale of Plant. – On Friday, the 17th inst., the stock and plant of an electrical engineer, comprising handsome electroliers, Gramme and other dynamos, screw cutting and other lathes, fly presses, vices, and other tools, launch and model engines, and miscellaneous electric and gas fittings, etc., will be sold by Mr. J. C. Stevens at 38, King street, Covent Garden.

Tenders for Lampposts. – The Waterhouse Electrical Manufacturing Company, Limited, of 33, Old Broad street, E.C., invite tenders for the supply of electric arc lampposts. Specifications and forms of tender may be obtained on application to the secretary of the company on payment of £2 2s., which sum will be returned on receipt of a *bona fide*, not later than Saturday, 18th November.

Whitehaven. – The Electric Lighting Committee of the Whitehaven Trustees have recommended that the tender of the Asby Colliery Company for the supply of coal to the electric lighting station for six months, being the lowest, be accepted, and that the tender of Mr. R. S. Cousins for entrance gates and posts to be erected at the electric lighting station, being the lowest, should also be accepted.

Tenders Wanted for Plant. – Tenders are invited for the whole of the plant of the Halifax Mutual Electric Light and Power Company, Limited (in liquidation), as a going concern, and consisting of engines, dynamos, switchboards, overhead cables, arc lamps, etc., for an output of 90 kilowatts. The plant can be seen by appointment any evening. Tenders to purchase to be delivered to Mr. William D. Taylor, Town Hall-buildings, Halifax, on or before Wednesday, the 15th inst.

City of Winchester. – At the last meeting of the Town Council a resolution was adopted confirming the award of Mr. Morgan Williams in the matter of the premium recently offered by the Corporation for the most suitable scheme for the lighting of the city. As the result of his exhaustive report on the whole of the schemes, the premium was awarded to the one submitted by the Brush Electrical Engineering Company, the estimated cost being £25,000. The town is at present lighted by oil lamps.

Central American Public Works Company, Limited. – This Company has been registered with a capital of £100,000 in £10 shares. The object is to acquire any real or personal property, and any concessions, rights, or claims in, or to be exercised in, Central America, to construct, maintain, and generally turn to account rail and tramways, piers, bridges, ferries, canals, roads, telegraphs, telephones, also, as builders and contractors, engineers, land agents, etc. The first signatories are: A. W. Higgs, G. S. Bonney, A. H. Downes, H. Robbins, A. W. King, G. G. Nicholson, and A. C. Taylor.

Wrexham. – The town clerk mentioned at a meeting of the Council last week that he had forwarded the resolution as to the purchase of the provisional order of the electric light company, and that he had received a letter from Messrs. Lewis and Son that the matter would be laid before the Board. The Town Clerk said there was an offer from the National Telephone Company to the Corporation to provide a connection with the company's exchange in the Wrexham district for one year, free of all cost, to facilitate communication with the fire-engine station. Mr. Benson moved that the offer be accepted, and the resolution was carried.

Tenders for Bolton.—The Gas and Lighting Committee of the Corporation invite by the 18th inst., tenders for the supply and erection of switchboards, accumulators, connections, etc. Specifications, plans, and forms of tender may be obtained on application to Mr J. H. Rider, M.I.E.E., borough electrical engineer, Town Hall, Bolton, on payment of £1. 1s., which sum will returned on receipt of a *bonâ fide* tender. Sealed tenders, upon the prescribed form, endorsed "Switchboards," must be addressed to Mr Alderman Miles, chairman of the committee, at the Gas Offices, by 18th inst.

Tenders for Newport (Mon.)—The Corporation invite, by the 20th inst., tenders for the supply and erection of steam boilers, feed water heaters, economiser, pumps, mechanical stokers, forced draught apparatus, steam exhaust, and water pipes, condenser, tanks, steam-engines, driving ropes, oil filter, alternators for incandescent lighting, dynamos for arc lighting, switchboards, instruments, arc lamps and lampposts, cables, culverts, surface boxes, junction boxes, converters, converter boxes, converter cases, switches, fuses, meters; also day load plant, to consist of semi-portable engine, alternator and exciter and switchboard, etc. Further particulars were given in our last issue.

Tenders for Sunderland.—The Corporation invite tenders by the 17th inst. for carrying out the work comprised in any or all of the following contracts: (1) Lancashire boilers. (2) High speed compound engines, dynamos, pumps, steam and other pipes, etc. (3) Motor alternators, switchboard, etc. (4) Main switchboard, instruments, and connections. (5) Batteries. (6) Insulated cables, etc. (7) Roadwork (*a*) construction of culverts, laying of cast iron pipes and casings, and building service boxes; (*b*) supply of cast iron pipes, casings, and service box frames and covers; (*c*) supply of stoneware casings and insulators. (8) Copper strip. (9) Gun metal grip boxes. Further particulars were given in our last issue.

The Empire Palace, Bristol.—Messrs. Vaughan and Brown, of London, E.C., have just installed the electric light throughout this building. They have made and fixed massive egg shaped lanterns in brass and glass for the main auditorium ceiling, elegant three arm brackets in ornamental polished brass and coloured glass round the gallery and balcony fronts, also massive electroliers and standards in the stalls, balcony bars, and front entrances. This firm have also installed gas fittings throughout the building, and have fixed in the main ceiling, with ventilating shafts, one of their large patent sun burners. They have carried out the whole of the work in four weeks, under the supervision of the architects, Messrs. Wylson and Long, of London.

Charging an Electric Launch.—An action brought by the General Electric Power and Traction Company Limited, against Mr. Sargeant was heard in the City of London Court on Tuesday. The plaintiffs, of Queen street chambers, claimed £2 against the defendant, Mr W. S. Sargeant, of Twickenham, for charging an electric launch to his alleged order. The plaintiffs' case was that they charged the defendants' launch "Florentia" with electricity to the order of the defendant's servants. The defendant said that he never gave the plaintiffs any order to charge the launch. The defendant was called as a witness for the plaintiff, and he then stated that he had given his servants no authority to give an order. He gave all orders on a printed form. Judgment was given for the defendant, with costs.

Dublin.—An enquiry has been held with reference to an application by the Corporation for a loan of £21,400 for the purpose of extending the electric lighting of the city, and to meet the increased demand from private consumers. Mr Harty alluded to the fact that the private lighting plant was now equal to 5,000 16 c.p. lamps, the number of lamps being 6,500. Stephen's green, Dawson street, Nassau street, Merrion square North, Leinster street, Clare street, part of Merrion square West, Capel street, Mary's lane and a number of other streets are included in the scheme. Mr Robinson, chairman of the committee, stated that the works already erected had proved such a success that the additional outlay would amply recoup them, as a greater number of consumers would be supplied.

Hull.—Two 750 ampere "O.E." meters have been ordered from the maker (Mr. Joseph Edmundson, Albert Electrical Works, Bradford) for registering the total output of the Hull electric lighting station. They are to be coupled to the two outside conductors of the three wire system. An effort is being made to induce the North Eastern Railway Company, as owners of the docks, to take up the question of lighting the docks with the electric light. It is believed that Messrs. Wilson and Co. will be asked to co-operate with the Corporation in bringing about this much desired improvement. The suggestion is that the Corporation should lay down mains with the view of illuminating the quays, sheds, etc., an operation presenting no difficulty, seeing that the central station is situated close to the dockside. The result of the experiment made by the Corporation in introducing the electric light into the town has so far proved a gratifying success, so much so that a reduction in the price to consumers on an early date is confidently expected.

Glasgow.—The minutes of the Gas and Electric Lighting Committee presented at a meeting of the Town Council a few days ago, stated that at a meeting on October 11, Mr. Arnot, the electrical engineer, had submitted the statement of cost which he had been instructed to prepare. The joint sub committees having considered the statement, were unanimously of opinion that, in the whole circumstances, it will be more convenient and expedient to make arrangements for charging the accumulators required for lighting the cars at one or more of the car depôts now being erected by the Corporation instead of getting this done at the existing central electric lighting station in Waterloo street. The minute was approved. At a meeting of the sub committee on galleries on October 20, a verbal report was made by the curator of the galleries as to the cost of lighting the Corporation Galleries by gas, and the report by Mr Arnot as to the cost of lighting them by the electric light having been reconsidered, it was resolved to recommend that electricity should be adopted throughout the galleries, and that the Crompton lamp should be used. The minutes were approved.

Mill Lighting.—The Rock Mill, Waterloo, has been lighted throughout by electricity by Messrs. J. H. Holmes and Co., of Newcastle on Tyne. The installation consists of two dynamos, the larger of which is capable of supplying the whole of the light in the mill; the other is a pilot dynamo for 150 lights for use when the main engine is stopped. The output of the large dynamo is equivalent to lighting 770 lamps. It is driven by belt from a countershaft driven by the mill engine. The pilot dynamo is driven by ropes from the flywheel of a special engine erected by Messrs. Holmes, running at a speed of 175 revolutions per minute. The lamps, which are all of 16 c.p., are provided, in the spinning and carding rooms, etc., with wide, shallow reflectors, painted white, which distribute the light thoroughly without casting a shadow on the cotton. In the staircase and engine room specially strongly guarded fittings are used. The work has been carried out under the superintendence of Mr. Broadbent. An installation comprising 300 lamps has just been put up by Messrs. Bennett and Druce of Preston, in the cotton mill of Mr J. Humber, Preston. The same firm are also equipping Messrs. Hartley Bros.' mills at Preston.

Wolverhampton.—The annual reports of the various committees of the Town Council were presented at the meeting of the Council yesterday. The Finance Committee reported that it would be necessary at an early date to issue Corporation stock or debentures to meet an account for permanent works, together with the amounts required for works of drainage, electric lighting, paving of streets and footpaths, East end Park, refuse destructor, and other general works of a capital nature which are intended to be carried out during the next few years. The question of providing the electric light for the borough was dealt with by the Lighting Committee, and after referring to the appointment of Mr. F. H. Lewis as electrical engineer and architect for the building of the central station, the report states that plans and specifications are being prepared and the engineer is negotiating with the Electric Construction Company, with a view of obtaining a modified tender from them for the plant and machinery necessary to supply electricity for 5,000 incandescent lamps and 40 arc lamps for street-lighting, also with Mr John Thompson for boilers, and Messrs. Calender and Co. for the laying of cables, etc. The architect is also preparing plans for the buildings.

Taunton.—A report on improvements and additions to the station has been sent to the Electric Lighting Committee of the Council by Dr. Fleming. The report deals with (1) additions to boiler plant, (2) additions to dynamo plant, (3) small improvements in the station, and especially an alteration of the steam-piping, (4) laying of the mains underground. Dr Fleming says that the two Babcock boilers now in use are in fair condition. Practically the whole boiler power in the station is in use at the time of heaviest load, and there is no other reserve boiler power in case one of the boilers breaks down; nor is there any possibility of extending the lighting without overloading the boilers. He therefore recommends the committee to lay down an additional boiler of 100 h.p., and that this boiler should be devoted to the arc lighting station. He recommends the acceptance of the tenders of Messrs. Davey, Paxman, and Co. for a steel boiler at the cost of £385, together with £50 for setting it. It is necessary, he says, to put in at once a small alternator to take the load at times when it is very far below the full capacity of the two present alternators. He also recommends that to drive this machine an engine capable of undertaking about 40 h.p. will be required. Under these conditions he expects to produce a marked economy in the coal. The present Willans and Ruston and Proctor engines require overhauling. He points out that it will be necessary at once to commence putting some of the mains underground. He proposes to get rid of the small house transformers, or to keep them for the "pioneer" work and to supply the central portion of the town from one common set of transformers, to be placed in sub stations. From these sub station transformers, underground mains will proceed to the customers.

Swansea.—For some years there has been a good deal of talk about the necessity and the advisability of lighting the main public streets by electricity instead of gas, and of supplying such of the business and residential premises as fall within the central area with this illuminant. During the last two months applications have been made to the Swansea Corporation by several electric light companies who have given notice of their intention to apply to the Board of Trade for a provisional order to enable them to light Swansea with electricity. In 1889, in the Corporation Act of that year, the Swansea municipality obtained an order from the Board of Trade enabling the Corporation to supply electricity for the lighting of the public streets, and for the supply of ordinary consumers within a certain area called the compulsory area, within which limits experiments might be tried, after which, if found successful, it might be extended to a wider region of the borough. Up to the present the Corporation have taken no steps to use their powers for the electric lighting of the borough. But the time is come, says a local paper, when the Corporation must arrive at a decision one way or another. Last week a meeting of the Electric Lighting Committee of the Corporation was held, when it seemed to be the unanimous opinion that it would be a fatal mistake for the

Corporation to allow their electric lighting powers to pass from them into the hands of any private company. The Board of Trade is to be communicated to the effect that no such powers should be granted to any private company until the Corporation have taken steps, as they will at once do, to clear up the matter and arrive at a decision whether they should use or give up the powers they now possess.

Metropolitan Electric Supply Company, Limited. — The following circular was issued on Monday to the shareholders by Mr. F. Cunliffe Owen, the secretary to the Company: "In fulfilment of the desire expressed at the last annual general meeting that the shareholders should be informed as to the Company's progress during the present year the Board have pleasure in stating that the increase of business is being satisfactorily maintained. The number of lamps connected to the Company's system, which in November, 1892, amounted to 114,656, and at the date of the general meeting in April last to 131,453, now amounts to 157,356, and additional applications are in hand for the supply of current to 7,557 lamps. The gross revenue for the six months ending June 30, 1893, shows a very satisfactory advance upon that for the corresponding period of 1892, while the working expenses for the same period fully bear out the views which the Board have frequently expressed as to the small additional cost of production as compared with the increased revenue earned. The gross revenue for the quarter ending September 30 shows that the rate of increase over 1892 continues. The patents relating to the manufacture of incandescent lamps expire on the 10th of the present month, and consequently great reductions in the prices of these lamps are of course being made. While it is difficult to foresee all the results that may arise from a change of so much importance to consumers, there can be little doubt that this Company must benefit by anything which tends to cheapen and popularise the use of the electric light. The Board are so satisfied with the present progress of the Company, that they have no doubt they will be in a position to recommend the payment of half yearly dividends in future years."

One Result of the Coal Strike.—Mr. Dewdney, solicitor, appeared at the Southwark Police Court, on Wednesday, on behalf of the City of London Electric Light Company, Limited, to answer a summons taken out by Inspector Grist, representing the St. Saviour's District Board of Works, Southwark, for an infringement of the Smoke Nuisance Abatement Act by allowing black smoke to issue from their premises at Bankside on several days during the month of October. Evidence having been given by the inspector in support of the summons, Mr. Dewdney said the company did not dispute the facts, but wished the magistrate to take into consideration the circumstances under which the cause of complaint had arisen. The fact was that, in consequence of the coal strike, they were unable to obtain a supply of Welsh smokeless coal for which they had contracted, although they had offered 10s. per ton more than the contract price. In consequence of this they tried to keep their works going by burning coke at considerable inconvenience and increased cost, but after a short time the coke supply also failed, but they were left on the horns of this dilemma: either they must stop their works, which it was impossible for them to do without breaking their contract for the electric lighting of the City, or use other coal, which they could not burn without subjecting themselves to the penalties for which they were now sued. He was happy to say, however, that their difficulty was now at an end, and that for the last week or two Welsh coal could again be obtained, and the company hoped to be in a position to give no further cause of complaint. Mr. F. H. Jackson, the company's engineer, was called in support of the foregoing statement, and after hearing his evidence, Mr. Slade said he would adjourn the case for four weeks in order to see, before giving his decision, whether the nuisance had been abated. This case was adjourned accordingly.

Lighting the Beaconsfield Statue.—At the Westminster County Court, on Tuesday, Judge Lumley Smith had before him the case of the Electric Installation Company v. Juliet, which was a claim by the plaintiff firm for out-of-pocket expenses in connection with the hire of lamps, wires, etc., in connection with an order from Madame Juliet, of Albemarle street, for the illumination of the Beaconsfield statue in Parliament-square, on Primrose Day. Mr. Marriott, solicitor, appeared for the plaintiff company; and Madame Norton, defendant's manageress, represented defendant. John G. O'Brien, plaintiffs' manager, said his firm gave an estimate for illuminating the Beaconsfield statue with incandescent lights. Madame Juliet, a florist, of 1a, Albemarle-street, came and said she had an order to do it from the Primrose League. The estimate was £3. 3s. in the end, as defendant said she would see that plaintiffs were mentioned in "all the Press notices." They got the batteries, etc., from the Electrical Storage Company, and had paid £1 7s. 6d. for the hire of them. They went to Parliament-square, but were not allowed to operate on the statue, as they could show the police no authority but defendant's. This, with the men's expenses, was now claimed. Madame Norton said the work was never carried out. Madame Juliet was sent for by Mr. George Lane Fox to do these illuminations. The Grand Ladies' Council of the Primrose League thought it would be a novelty to have the statue illuminated. The contract was never carried out, then why should defendant pay? His Honour: The plaintiffs received an order from you, and would have carried it out. It was not their fault. Madame Norton: We had Mr. George Lane Fox's word they had permission to do whatever they liked with the statue on Primrose Day. Surely, his word was good enough? His Honour: Well, you must get it back from him. I suppose the ladies thought it would be a novelty. Madame Norton: Yes; they all wanted it done—the Countess of Durham and all the others. His Honour said plaintiffs' claim had been made out to the extent of £1 17s. 9d. They must have judgment for that amount, with costs.

Barrow.—At a meeting of the County Council held last week Councillor Smith moved the following resolution, of which he had given notice: "That, in face of the many recognised advantages of electricity over gas as an illuminant, and its rapidly increasing adoption by other towns, the resolution of the Council of April 6, 1891, authorising the provision, at an estimated cost of £3,000, of certain additional plant at the gasworks to meet the increasing consumption of gas, be rescinded, and that the resolution of the Council of the same date, approving the proceedings of the Gas and Water Committee of March 25, 1891, be varied or rescinded so far as such proceedings approve the proceedings of the 'Additions to Gasworks Plant Sub-Committee of March 24, 1891.'" He said that his motion rose out of the motion he made at the last Council meeting. While there was naturally difference of feeling on the question of the electric light for Barrow, most of the members of the Council would agree with him that they should not expend any more money in increasing the capacity of the gasworks. Councillor Bradshaw seconded the motion. Alderman Strongitharm thought Mr. Smith's motion absurd, and if the mover and seconder thought they were going to advance the electric light question by endeavouring to cripple the development of the gasworks, they would find the majority of the Council against them. Other speakers having spoken against the motion, Councillor Smith, in reply, said that one of the principal objections raised against the electric lighting scheme had been that they had sufficient capacity at the gasworks, but now the argument had gone to the other side, and was strongly in favour of the electric light. It was quite possible with an expenditure of £4,500 or £5,000 they might get a very great increase in the capacity, but this did not alter the other side of the question at all for if they were not anxious to do it now they would be forced to do it next year whether they liked it or not. The motion, on being put to the meeting, was rejected.

Aberdeen.—The Gas Committee of the Town Council have had applications as to an extension of the electric lighting mains for the supply of private consumers in King street, Market street, and Rubislaw terrace. With regard to Rubislaw-terrace, the committee directed that a reply should be returned to the effect that the committee did not see their way in the meantime to recommend the Council to undertake the cost which would be involved in carrying out the extension required. As regarded Market street, the committee authorised the laying of the main for the distance required, the estimated expense being £75; and, with respect to King-street, remitted the application to the superintendent, with powers. These recommendations have been adopted. The Watching, Lighting, and Fires Committee of the Town Council reported, at a meeting a few days ago, that they had under consideration the question of introducing electricity for street-lighting purposes within a certain area. In this connection they had before them a report from the superintendent of the gasworks and the lighting inspector to the effect that, after consultation with Mr. Murray, electrical engineer to the Corporation, in their opinion at least nine lamps of about 2,000 c.p. would be required to light Castle street and Union street (as far as Union Bridge), and one lamp to light St. Nicholas street, and to which reference was made in our last issue. The average distance between the lamps would be about 77 yards. The cost of the scheme, including pillars, lamps, and erection, would be about £252 10s., and the cost of maintenance and current per lamp about 2½d. per hour. The committee resolved to recommend that nine arc lamps should be erected in Castle street and Union street (as far as Union Bridge), and one lamp in St. Nicholas street at the junction of Correction Wynd, according to the plan submitted, and that the Council should remit to the superintendent of the gasworks and the lighting inspector to take the necessary steps for this purpose. Bailie Lyon, in moving the adoption of the report, said that when the Gas Committee made arrangements for getting the electric light into the central district of the city precautions were taken so that the streets could be lighted without taking up the pavement again, and at the present moment the whole thing was completed for all the streets in the area to be lighted, with only the cost of putting up the lamps. Mr. Sinclair seconded the adoption of the report, which was carried.

Trades and Industries Exhibition at Newcastle.—An exhibition of this character was opened at Newcastle on Monday. In the engineering department there is an electric light installation by Messrs. Ernest Scott and Mountain, Limited, of the Close Works, Newcastle. This consists of a 12-unit Tyne compound-wound dynamo, capable of feeding 20 2,000 c.p. arc lamps. The dynamo is driven by an Otto gas engine of 16 h.p. A second dynamo is installed, capable of feeding eight 2,000 c.p. arc lamps to be used at the entrance and in the refreshment-rooms, this being driven by a 4-h.p. gas-engine. The interior of the building is lighted by means of 12 Tyne arc lamps of 2,000 c.p., and three similar lamps are placed outside. Messrs. Ernest Scott and Mountain exhibit, also, a high-speed vertical engine of their own manufacture for electric lighting, a combined engine and dynamo for shiplighting, and a triple-feed pump for working in connection with auxiliary condensers and feed-heaters, and specimens of brass castings. A complete electric light installation is shown by Messrs. Rowland, Barnett, and Co., of Newcastle. It consists of a dynamo driven by a 12 h.p. nominal Stockport gas-engine. The dynamo is capable of giving an output of 100 amperes at an E.M.F. of 65 volts when running at from 400

to 450 revolutions per minute. It energises six arc lamps, varying in power from 500 to 3,000 candles, and numerous incandescent lamps, arranged on a board showing the various fittings are on view. Messrs. Rosling and Matthews, Bradford, exhibit dynamos and other electrical appliances. Messrs. Furnival and Co., of Reddish, exhibit a ½-h.p. and a 4 h.p. silent gas-engines, and on the adjoining stand is a series of exhibits by Messrs. Tangyes, Limited, of Birmingham. The Otto engine, with Pinkney's patents, is shown in motion. Messrs. J. E. H. Andrew and Co., Limited, of Reddish, exhibit through their agents, Messrs. Allen and Robson, a 12 h.p. nominal and 24 h.p. actual Stockport gas-engine, specially fitted for electric lighting, with two extra heavy flywheels and electric light governor, etc. The same agents show, for the Blackman Ventilating Company, Limited, an air fan driven by a gas engine, and a fan and an electric motor combined. The Campbell Gas Engine Company, Limited, Newcastle, have on view two horizontal gas-engines, of 3 h.p. and 8 h.p. nominal, and a 3 h.p. oil engine. Messrs. Peter Burt and Co., of Camlachie, Glasgow, exhibit an Acme patent horizontal gas-engine of 6 h.p. nominal. Gas-engines are also shown by Messrs. Crossley Bros., of Openshaw. A large stand is occupied by Messrs. Thwaites Bros., Limited, Bradford, and contains a "Capell" centrifugal pumping engine, capable of discharging 100,000 gallons, or about 450 tons per hour; a combined pump and electric motor; an improved Roots blower and duplex engine; a 5 cwt. steam hammer; a rapid cupola model, the "Andrew Howatson" patent industrial filter, water softener, patent diurnal water softener, etc. Messrs. Grenfell and Accles, of Birmingham, exhibit a band milling machine, sensitive drill press, tapping machine, and two capstan head lathes on screw machines. The exhibit is designed especially for electrical, cycle, gun, and other concerns where a number of pieces are to be made in duplicate, or where quantities of good screws are required. In connection with this stand are shown examples of self-winding electrical clocks by the Industrial and Mercantile Investment Company, London, through their agents, Messrs. John Mills and Sons, Newcastle and Walker.

Grimsby.—It was mentioned in our last issue that the Town Council had decided to have an interview with Mr. Hammond on the subject of electric lighting. That interview has now taken place, the following being an abstract. The Mayor, in introducing Mr. Hammond, reminded the meeting that having resolved to apply for a provisional order in respect of electric lighting, it was necessary to have some information on the subject. He met Mr. Hammond a little while ago, and that gentleman very kindly offered to come down to give any information which the Council desired. Mr. Hammond first referred to the great superiority of electricity over gas as an illuminant, and then to electrical science and engineering from the early days down to the present. Having described Faraday's methods, he described in detail a central electric station erected on modern lines, advocating steam power in preference to gas as an agent for working the machinery. He also advocated the cutting up of the power in order to keep it in proportion to the amount of electricity required at various periods, and so economise the motive power and at the same time be able to guarantee a constant supply of electricity. In other words, the central supply should not be dependent upon one large engine, which would have to be kept going when only a very small amount of light was wanted, but upon a number of smaller ones which could be brought into use or not as occasion required. Coming to the capital outlay, he said he had endeavoured, by going rather closely into the engineering portion of the subject, to show that it was a very simple thing, that when the plant was properly laid there was no reason why the light should not be supplied without fluctuation from one year to another, and that money invested in electricity works was not invested in a new or unsound thing. Electric lighting undertakers, as they were called, were compelled to file their accounts in a form drawn up by the Board of Trade, and they had to distinguish between their expenditure in coal, wages, works, repairs, maintenance, directors' expenses in case of companies and management expenses in connection with corporations, and not only so, but they must supply the Board of Trade with the number of units turned out at their works, so that it was possible to discover exactly what was done in every electric lighting works. A Board of Trade unit was about 1,000 watts for an hour, equalling 30 lamps of between 8 c.p. and 10 c.p. burning for one hour, or one lamp for 30 hours. In St. James's, London, the Board of Trade unit was produced at 2½d., though their parliamentary powers enabled them to charge 7d. At Bradford, where the works belonged to the Corporation, the cost of production was 2d. per unit, and they only charged 5d. per unit—though they could charge 8d.—and the margin between 2d. and 5d. represented the amount which could be annually set aside for a sinking fund to wipe off the cost of the work. A number of other places were referred to, where margins of 3d., 3½d., 4d., 5d., 6½d., 7d., and 8d. per cent. existed between the cost of production and the price of supply. Thus, where a corporation was in a position to borrow money at 3 per cent., the figures quoted enabled them to do so and to provide a good sinking fund. In the earlier days of electricity the work had been almost wholly done by companies, but it was now being done by corporations, which was owing to the more advantageous conditions brought about by the amended Act of 1888. At the present time there was invested in the electrical industry some four and a half millions—a very surprising figure considering the waste of money in the early days. Of the four and a half millions invested, four millions had been subscribed by companies and only half a million by corporations. There were, however, certain electrical works in course of construction representing £845,000, of which £79,000 was subscribed by companies and £766,000 by corporations. In addition to this there were works actually decided upon representing £820,000, of which £25,000 was in respect of companies and £795,000 in respect of local authorities. These figures showed a total of 6¼ millions invested in electrical works, of which four millions were invested by companies, whilst the amount invested by local authorities had crept from £500,000 to over two millions. He went on to show that specifications could now be got out without waste of money, mentioning that in a recent case, where he prepared the estimates for works costing £25,000, there were only £58 for extras, part of which was for things not really necessary to the scheme. He pointed out there was no defined limit to the uses of electricity; there was no knowing what that mighty force might yet be used for, and in placing down plant the Corporation could, under proper advice, place itself in a position to supply anything which might be wanted. Mr. Connell asked whether Mr. Hammond's experience proved electricity to be suitable for exterior lighting? Mr. Hammond expressed himself thoroughly in favour of the arc lamp. It brought business to a place, and in some instances reduced the expenses of the Watch Committee. Where arc lighting had been properly started from the central station it had never, to his knowledge, been given up. In answer to other queries, he remarked that as time went on there was every possibility of the cost of production being reduced, as it had been in the past. The best thanks of the Council were given to Mr. Hammond, who arranged to give a public lecture on the subject.

Kendal.—At a meeting last week of the Town Council and Urban Sanitary Authority, Councillor Hargreaves moved the following resolution: "That a committee be appointed to consider the expediency of applying, and the steps necessary for the Corporation to apply, for a provisional order to put in force the Acts relating to electric lighting within the borough, and to report." In doing so, he said that resolution required their serious consideration. It was not now necessary to go to the expense of a private Act, as in the case of gas. All that was required was to get a Local Government order at little or no expense, and then there was no difficulty in obtaining money to put in installations. As to the cost of the electric light, he had made enquiries of several high-class firms, and found that the Brush Company, for which Mr. Bevan Braithwaite, son of an old townsman, was agent, would be as reliable as any. In the first estimate he got from them he calculated for street-lighting 300 lamps of 16 c.p. and 32 c.p. That would give a much better light than their present system of gas. He also calculated for 1,500 lamps of 16 c.p. for private lighting. He thought on further consideration, that that installation was too small, as 1,500 lamps for private lighting would only allow for 150 houses and shops with 10 lights each, whereas he found from careful enquiry that many would take the electric light in hotels, clubs, shops, and houses requiring from 20 to 50 lights each. Therefore he asked for a revised estimate providing for 270 street lamps of 16 c.p. and 32 c.p., 30 arc lamps of 2,000 c.p., and 4,000 private lights, which would allow for, say, 200 shops, houses, hotels, etc., with an average of 20 lights each, and these revised figures he had got, and would read the report in full. The following was the report from the Brush Electrical Engineering Company: "(a) The cost of working an electricity supply station capable of dealing with fully 4,000 lamps of 16 c.p. burning at one time installed in private premises including all charges such as fuel, oil and sundry stores, attendance and supervision, repairs and depreciation of buildings, machinery and some mains, and additional municipal office expenses. (b) The extra cost of maintaining 270 incandescence street lamps, of which 170 are assumed to be of 32 c.p. each and the balance of 16 c.p. each; also 30 arc lamps of 2,000 nominal candle-power (say 1,000 actual). In our previous estimate we assumed a 'load factor' of 15deg., but in this case, and in order to be well on the safe side, we have assumed only 10deg.—that is to say, the probable earnings of such a plant is estimated as the equivalent of the running plant (neglecting spare in plant) fully loaded for only 876 hours out of the total 8,760 hours per annum. It will be obvious to you that any increased sale of current beyond this assumption will reduce the cost per unit, as many of the charges making up the total cost would be increased by trifling amounts, if at all, such as attendance, supervision, repairs, and depreciation on plant, etc. The total cost on the above basis is, however, only 3d. per unit. In this connection we may be allowed to point out that the efficiency of the various items of plant, such as boilers, engines, dynamos, and transformers, has a most important bearing on the total cost, and in view of the fact that by the very nature of the load on an electric light station the plant is working for a very large proportion of its time lightly loaded, the 'constant' or 'light load' losses must be reduced to a minimum to ensure the best all the year round result. Many local considerations affect the choice of system, but we are in an exceptionally favourable position to tender on any of the alternative methods—high or low tension, direct or alternating current—as we are manufacturers of all these types of plant. We enclose a list of towns which have established—or are about to establish—an electric light station. The large proportion which have, after investigation, adopted the alternate-current transformer system is significant when it is borne in mind that its introduction is of such recent date compared with its rival, the direct-current system. We may, therefore, assume for the moment that it would best meet the Kendal conditions. This being the case we have only to refer you to the list to establish our fitness to undertake a complete electrical equipment for your Corporation, inasmuch as we have had more experience in this direction than all our competitors in this country combined, and as regards efficiency of plant, the fact that the two companies making the lowest charge to consumers in Great Britain—viz., Newcastle-upon-Tyne Electric

Supply Company 4·05d. net, and Chatham and Rochester E.S. Company 4½d net—are both using our plant speaks for itself. Having standardised the various items of our system upon the results of our large experience, you may have every confidence in placing this important work in our hands, and by adopting such standards in their entirety you would both minimise the first out lay and leave with us an undivided responsibility for the success of the whole undertaking. From our past experience of installations of similar size we should expect the whole installation referred to in the maintenance estimate to cost you about £21,000, including buildings, spare steam and electric generating plant, the arc and incandescent street lamps, and a complete system of underground mains. The cost to the consumer for the first outlay in 'wiring' his premises depends, of course, upon the character of the premises, but the following prices per lamp may be taken as fairly representing the total cost, including lamps, simple fittings, conductors, switches, cut outs, and accessories: Private residences, per lamp, 26s. to 30s.; shops (in straight rows, etc.), 20s. to 24s.; warehouses and factories, 18s. to 25s." Mr Hargreaves next gave in detail the actual working results of 10 companies. He had not gone into the question of water power because he was under the impression that they had not in this neighbourhood sufficient water power for an electric installation. If anything was done it would be simply as an auxiliary. Alderman T. Wilson moved as an amendment that Mr Hargreaves be recommended to postpone the bringing forward of his resolution until they had concluded their negotiations with the gas and water company. This was seconded and on being put to the meeting 15 voted for deferring the question and seven for the appointment of a committee, the motion being therefore lost. It was then agreed that the thanks of the Corporation be given to Councillor Hargreaves for the information he had laid before the meeting. Councillor Hargreaves moved that they ask the Brush Company to send down an engineer, so that a report could be in their hands by the day appointed for the meeting to deal with the question of the purchase of the gas and water concern. Councillor McKay seconded, and remarked that they would not be doing their duty to the ratepayers of Kendal if they went in for the gas scheme with the figures now before them. It would be simple madness if they bought that concern without getting figures and an estimate of electric lighting after what Mr Hargreaves had put before them to-day. Further discussion ensued, but the motion was rejected.

PROVISIONAL PATENTS, 1893.

October 30.

20458. **An electric switch.** Edward Carstensen de Segundo, 28, Southampton buildings, Chancery-lane, London. (Complete specification.)

20459. **Improvements in suspension devices for electric crown lights and the like.** Eugen Rodantz, 323, High Holborn, London.

20471. **Improvements in incandescent electric lamps.** James Graham Tatters, 24, Southampton-buildings, Chancery-lane, London.

20493. **An improved electric flash light clock.** Herbert Young Dickenson, 56, Gray's inn road, London.

October 31.

20551. **A new or improved switch and cut-out for electroliers.** Henry Birkbeck, 34, Southampton buildings, Chancery-lane, London. (The Universal Pull Socket and Switch Company, United States.)

20557. **Improvements in electrical switches.** Eugen Rodantz, 8 Lord street, Liverpool.

20584. **Improvements in the manufacture of elements for electric or secondary batteries.** Augustus John Marquand and Emanuel Hancock, 24, Southampton-buildings, Chancery lane, London.

November 1.

20625. **Improvements in and connected with carbon electrode connections.** Harry Theodore Barnett, 14, Narcissus road, West Hampstead, London.

20686. **Improvements in electrical condensers.** William Ernest Gray and William Arthur Price, 6, Bream's buildings, Chancery lane, London.

20696. **Improvements in and in connection with electric cables.** George Gatton Melhuish Hardingham, 191, Fleet street, London. (The firm of Felten and Guilleaume, Germany.) (Complete specification.)

November 2.

20723. **Improvements in electric measuring instruments.** Walter Thomas Goolden and Sydney Evershed, 1, Woodfield road, Harrow road, London.

20732. **An electrical or mechanical apparatus in connection with a ship's sounding lead, or for cognate purposes.** William Aldred, 5, Brightside bank, Brightside, Sheffield.

20741. **Improvements in swing or movable joints especially adapted for electric light fittings.** James Aram Lea, James Francis Lea, and Arthur Henry Lea, Pengwoone Works, Chester street, Shrewsbury.

20788. **Improvements in electric stop motions for warping machines.** *Clayton Dean, John Cocker, and Charles Dean, 53, Chancery-lane, London.*

20735. **Improvements in lightning conductors.** Joseph Ball, 4, Corporation street, Manchester. (Complete specification.)

20793. **Improvements in recording instruments for electric telegraphs.** Alexander Muirhead, 124, Chancery-lane, London.

20799. **Improvements in electric incandescent lamps.** Marie Henri Hartogh, 37, Chancery-lane, London. (Complete specification.)

20816. **Improvements in connectors for electric conductors.** Herbert Rudolph Keithley, 45, Southampton-buildings, Chancery-lane, London.

November 3.

20837. **Improvements in electrostatic and other electrical measuring instruments.** William Edward Ayrton and Thomas Mather, The City and Guilds of London Central Institution, Exhibition road, London.

20840. **Electric firedamp indicator.** Albert Ebenezer Schurr, Lyncot, Leigh on Sea, Essex. (J. Cauderay, Switzerland.)

20847. **Improvements in carbon brushes blocks or collectors for electric generators and motors.** William Harding Scott, Gothic Works, King street, Norwich.

20859. **A process by which by combined chemical and electrical action he obtains motive power.** Frederick Gwilym Trehane, Llyndérw, Llanishen near Cardiff.

20883. **Improvements in brackets or supports for insulators for telegraphic telephonic, and other like purposes.** Bullers Limited, and Edward John Chambers, 7, Staple inn, London.

20887. **Improvement in incandescent lamps.** Arthur Stephen Ford and William Barnes, 12, Basinghall street, London. (Complete specification.)

20891. **Improvements in phonographs and telephones.** Philip Arthur Newton, 6, Bream's - buildings, Chancery lane, London. (Alfred Nobel, France.)

20896. **Apparatus for working semaphore signals by means of electric currents.** Siemens Bros. and Co., Limited, 28, Southampton buildings, Chancery-lane, London. (Messrs. Siemens and Halske, Germany.)

November 4.

20915. **Improvements in alternate - current synchronisers.** William Edward Ayrton and Thomas Mather, Central Institution, Exhibition road, London.

20923. **Improvements in the means of charging and discharging primary electric batteries.** Harry Theodore Barnett, 14, Narcissus road, West Hampstead, London.

20966. **Improved incandescent electric lamp.** John Plummer, Colinton, Midlothian.

20975. **Improvements in voltaic batteries.** James Augustus Seymour Gregg, 28, Southampton buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1892.

18066. **Electric meters.** Golby. (Dejardin.)

18966. **Electrolytic decomposition of metals and sulphur.** Siemens Bros and Co., Limited. (Siemens and Halske.) (Second edition.)

21376. **Electrical resistances.** Edmunds.

21377. **Electrical conductors.** Edmunds.

22187. **Lightning arresters.** Belfield. (Westinghouse Electric and Manufacturing Company.)

22473. **Dynamo electric machines.** Brown.

23007. **Galvanic batteries.** Walker and Wilkins.

23054. **Electric induction coils.** Davis.

23902. **Alternate-current motors.** Brown.

1893.

12662. **Electrolysis.** Andreoli.

15681. **Electric accumulators.** Roe and Sutro.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13
Electric Construction	—	1¼
House-to-House	5	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	22¼
Liverpool Electric Supply	5	6¼
	3	4⅜
London Electric Supply	3	1
Metropolitan Electric Supply	—	7⅞
National Telephone	5	4¼
St. James', Pref.		8½
Swan United	3¾	3⅛
Westminster Electric	—	5¼

NOTES.

Traction in Italy.—It is proposed to construct an electric tramway between Milan and Corteolona.

Blackpool.—The use of the electric light is enabling the work on the tower to be more rapidly accomplished.

Kingston.—The Surrey County Council buildings at Kingston-on-Thames are lighted by electricity from the municipal station.

Bristol.—The Bristol Carriage and Tramways Company propose to apply for powers to introduce electric traction on their lines.

Recent Solar Discoveries.—A lecture on this subject was delivered by Sir Robert Ball on Monday at the London Institution.

Glasgow.—An explosion, which tore up some part of the pavement, occurred a few days ago in connection with the electric light conduits.

Newcastle.—The North-Eastern Railway Company propose to lay down an electric light installation on the property adjoining the goods station.

Carlisle.—An institute of literature, science, and art, as mentioned in another column, has been opened by the Mayor. The building is lighted by electricity.

Personal.—Mr. W. F. Taylor, consulting electrical engineer, of Boswell Court, Croydon, has been elected to the County Council of the borough of Croydon.

Battersea Town Hall.—The new Town Hall at Battersea, opened on Wednesday, is lighted by gas, the reason being that there is no public supply of electricity available.

Watts the Matter?—An esteemed contemporary, in referring to the lighting of a mill in its last issue, states that "the dynamo was tested for five hours continuously with a load of 55,000 volts"!

Telephony.—The erection of the trunk wire between Dover, Canterbury, Chatham, and Maidstone has been completed. It is expected that communication will be opened up with London by Christmas.

Electrotechnical Progress.—We have received a copy of *Fortschritte der Elektrotechnik*, being the fourth issue of this year. It is issued, under the auspices of Dr. Karl Strecker, by Mr. Julius Springer, of Berlin.

Cost of Electric Lighting.—We have received a copy of a table showing the total cost of electric lighting when using "Robertson" incandescent lamps of 16 c.p., at various efficiences, in watts per candle-power.

The Institution.—At the ordinary meeting on Thursday, the 23rd inst., a discussion will be commenced on the paper read last week by Prof. Forbes on "The Electrical Transmission of Power from Niagara Falls."

Traction at Ipswich.—The service of tramcars was discontinued on Saturday owing to the inability of the company to meet a certain payment to the Town Council. Electric traction does not appear to have been considered.

Electric Launches.—Launches of this type are to be used at Venice. On the 28th ult. a trial trip was made with one of these boats, constructed to carry 28 persons, and capable of being propelled at the rate of about 10 miles an hour.

"A Death Dealer."—Mr. Davis, the New York State executioner, is reported as about to apply for a patent for an electric death-dealing apparatus which he thinks will allow of the carrying out of the electrocution law without any trouble whatever in the future.

"Cassier's Magazine."—The London offices of this magazine have been removed to 5, Chandos-street, Strand. In the October number an account is given of the life and inventions of Edison, and a paper on improvements in cable-making. Besides these, the issue contains other interesting articles.

Submarine Boats.—The new submarine torpedo-boat, "Radatz," has undergone a successful trial on Lake Winnebago. The boat, which is 40ft. in length, is propelled and lighted by electricity. She carried three men, and on the occasion of the trial remained under water an hour under perfect control.

Zanzibar.—The Eastern Telegraph Company announce the laying and opening for traffic of the cable between Zanzibar and the Islands of the Seychelles, being the first section of the cable Zanzibar-Seychelles-Mauritius. The extension of the cable to the Island of Mauritius is expected to be completed by the end of this month.

Dr. Tibbits and Mr. Harness.—We are informed (says the *British Medical Journal*) that Dr. Tibbits, who was the plaintiff in the action of Tibbits *v.* Alabaster and Gatehouse, has been struck off the list of Fellows of the Royal College of Physicians, Edinburgh, for aiding Mr. Harness in selling "electropathic belts" which were declared to be worthless medically.

Omnibus-Lighting.—The prospectus is being issued of the Omnibus and Tramcar Electric Lighting Company, Limited, who will deal with lighting according to Mr. Pitkin's patents. The company will undertake the lighting of private vehicles from similar accumulators, etc., as supplied to the Lord Mayor's carriage—referred to in our last issue—or with the illumination of public carriages as now provided on the London street tramways, the London General Omnibus Company, and private omnibuses.

Birmingham Electric Cars. — The Birmingham Central Tramways Company have, after trying plates of another type for more than 12 months, decided to renew the whole of the battery with plates manufactured by the Electrical Power Storage Company, Limited. We understand that two batteries of the original plates manufactured by the Electric Construction Corporation (the then owners of the E.P.S. patents), and which were supplied more than two years ago, have been regularly working and giving excellent results.

Arbitration.—The Chamber of Arbitration established by the London Chamber of Commerce was considered on Tuesday at a meeting of the latter. Sir Albert Rollit, M.P., in a comprehensive address, remarked that he was in favour of arbitration all along the line whenever it was possible. At the close a resolution was passed approving of the formation of the Chamber of Arbitration, submitting that its machinery provides for rapid, cheap, and effective settlements of business, and recommending traders in the City of London to make use of the Chamber whenever differences arise in regard to the settlement of all points.

The Government and Telephony.—The delay on the part of the Postmaster-General in placing before Parliament his new agreement with the National Telephone Company is said to be exciting general remark in political quarters. The explanation is stated to be that the directors of the company have made some difficulty about assenting to certain provisions in the agreement. A correspondent believes, however, that the friction between the Post Office and the company has now been removed, and it

is thought that when the matter is mentioned in the House to-day, Mr. Arnold Morley will be in a position to make a definite and authoritative statement.

The Lyons Exhibition.—The Exposition Universelle Internationale et Coloniale in 1894 at Lyons, which has the support of the French Government and of the leading chambers of commerce throughout the country, bids fair, we are informed, to become the most important enterprise of its kind ever attempted on the Continent out of Paris, judging from the numerous applications for space which are pouring in from all parts. The Executive Committee has appointed Mr. Brandrethas, of the Anglo-Continental Contract Association, Limited, 52, Queen Victoria-street, E.C., their agent for Great Britain and Ireland, and they will supply those who may desire to exhibit with full information concerning terms and conditions on which spaces will be allotted in the British section.

The "Medical Battery" Company, Limited.—On Wednesday at the Marlborough Police Court, the hearing was resumed of the charges of conspiracy to defraud brought against Mr. C. B. Harness, Mr. J. M. M'Cully, and Mr. C. B. Hollier. After receiving evidence for the prosecution, the hearing of the case was adjourned for a week, the bail in the case of Mr. M'Cully being reduced to two sureties of £100. The application of Mr. Browne for the compulsory winding up of the "Medical Battery" Company, Limited, and which was deferred from last week, was again considered on Wednesday. Mr. Justice Williams ordered the voluntary liquidation to be continued for another week, the key of the minute-book of the company to be produced in the meantime.

Westminster Electric Supply.—In our article on the Westminster central stations, on November 3, dealing with Davies-street station, the curve given was inadvertently entitled "Load Diagram at Eccleston-place"; it should have been "at Davies-street station." With reference to last week's article on cost of generation, Prof. Kennedy wishes us to point out that the "chief engineer" to a company has so much to do with distribution, and also especially with the arrangement of new plant, that it would be incorrect to charge his salary entirely against generating expenses. Strictly speaking, part of his salary is for generating, part for distribution, and a part for capital account. The Westminster Corporation, however, put all to revenue, and charge it to central expenses so as to be fair. The important point is that the expense for chief engineer should be put to "revenue" and not to "capital," as is sometimes done.

"Sunbeam" Lamps.—A price-list of the "Sunbeam" incandescent lamps, which were first introduced in 1887, has now been issued by the Sunbeam Lamp Company, Limited, of Gateshead-upon-Tyne, and of 50, Fenchurch-street, E.C. We are informed that since the manufacture of these lamps was suspended owing to the existence of the master incandescent lamp patent, the company has been reorganised on a new basis, and that a large factory equipped with the latest improvements has been completed. The company is now turning out incandescent lamps of from 8 c.p. up to 2,000 c.p. The high candle-power lamps, which are specially suitable for lighting large areas, are made in two classes—namely, those of high efficiency and those of longer duration. Lamps to run in series are now provided for 5, 6, 8, and 10 ampere circuits, and of various candle powers. The company are making the "Sunbeam" lampholders in two sizes.

The Milan Tramway.—We have already mentioned *in a previous issue that* an electric tramway on the *Thomson-Houston system has* been constructed in Milan, and we now give the following particulars of the line, which has been constructed by the Società Generale Italiana di Elettricità Sistema Edison. The line, which is double, starts from the Piazza del Duomo and ends at the Corso Sempione. The generating plant, which is contained in the central station which supplies the current for the public lighting of the town, comprises two steam engines of 200 h.p., and two Thomson-Houston dynamos giving 200 amperes at 500 volts. There are 10 cars in service, each capable of accommodating 34 passengers. The cars are fitted with electric bells, and lighted at night by five 16-c.p. lamps. Each car is equipped with a 15-h.p. motor, which is capable of working at a higher power if necessary. The line was opened to traffic on the 2nd inst.

Telephonic Communication for Hospitals.—Writing to the *Times*, Mr. Alfred S. Gubb, M.D. (Paris), states that a wave of public opinion has at last overcome the inertia of the authorities and will shortly have been the means of placing the keepers of lighthouses and lightships in telephonic communication with their inland fellows—a simple and by no means costly convenience, which it has taken years to bring about. The success obtained in this direction suggests the possibility of inducing the governing bodies of our large general hospitals of London to avail themselves of the facilities afforded by the telephone for rapid and easy communication with other hospitals. A hospital is not a self-contained, independent, administrative entity, but a segment of the hospital administration of the metropolis, and he states that it is eminently desirable—nay, absolutely necessary—that each segment should be enabled to communicate freely and easily with the remainder.

Manchester and Telephony.—A matter of great importance brought up at a meeting of the Town Council on Wednesday was the reception of the report of the Parliamentary Sub-Committee, and the approval of the same by the committee. This showed what the committee had done in regard to the proposal of the telephone companies to obtain statutory powers for taking wayleaves and underground modes of conveying their wires. From this report it appeared that the Special Committee of the Municipal Corporations' Association came to the conclusion in August that it would be undesirable to grant these powers unless statutory limitations were imposed upon the undertakers, and subsequently had interviews with the Board of Trade and the Post Office authorities. The upshot of these exertions was that the Postmaster-General consented on September 11 to lay before Parliament the proposed agreement with the telephone companies before it was executed.

Electric Light Cables and Wires.—A new price-list of electric light cables and wires (vulcanised and unvulcanised indiarubber) has just been issued by Messrs. W. T. Henley's Telegraph Works Company, Limited, of 27, Martin's-lane, E.C., and North Woolwich. The list, which gives instructions for making joints, contains particulars of electric light wires composed of tinned copper (100 per cent. conductivity), insulated with pure and vulcanised indiarubber, and taped, the whole being vulcanised together and compounded; of similar wires taped or felted, vulcanised, then braided with yarn and compounded; vulcanised electric light cables similarly treated, concentric cables, lead-covered wires and electric light cables; electric light wires insulated with pure indiarubber, braided and compounded, cables insulated with indiarubber and not vulcanised; twin flexible electric light cords, wood casings, jointing materials, etc. It may be mentioned that [illegible] wires and cables referred to are te[illegible] immersion in water at 60deg.

electrification and the minimum insulation resistance is noted on each coil.

Brighton and Rottingdean Electric Railway.—The prospectus is being privately circulated of the Brighton and Rottingdean Seashore Electric Tramroad Company, which has been formed with a capital of £20,000, divided into 2,000 shares of £10 each. The company has been established to construct an electric tramway, together with landing stages, to provide a ready means of communication between Brighton and Rottingdean both for passenger and parcels traffic. The length of the line will be about three miles. It is not expected that more than £12,000 will be needed for building and equipping the line, and in the acquisition of the necessary land. Of the 2,000 shares 232 have been issued fully paid to the promoters in satisfaction of all costs, charges, and expenses of and incident to the preparing for obtaining and passing of the Act, and £4,000 has been subscribed by the directors. The present issue is 1,200 shares, payable £1 on application, £1. 10s. on allotment, two calls of £2. 10s. each, and the remainder as required. The offices of the company (of which Messrs. E. O. Blackley, J. J. Clark, A. J. Rawlinson, and M. Volk are directors) are at 58, Ship-street, Brighton. The directors have every confidence in the success of the undertaking.

Intensities of Lighthouse Lights.—The second meeting of a conference of the General Lighthouse Authorities of the United Kingdom and their engineers, together with representatives of the Admiralty and Board of Trade, has been held at Trinity House. It was decided to publish in the official list of lights the candle-power of each light as determined by the engineers. By this means mariners will be informed of the relative illuminating powers of all the principal lights on the coast. The members of the conference were Sir Sydney Webb, deputy master of the Trinity House, in the chair; Vice-Admiral Sir George Nares, F.R.S., of the Board of Trade; Captain Wharton, R.N., F.R.S., hydrographer to the Admiralty; Sir Robert Ball, F.R.S., scientific adviser to the Irish Lighthouse Board; Captain Burne, elder brother; and Mr. Charles A. Kent, secretary of the Trinity House; Sheriffs D. B. Hope and R. N. Campbell, Northern Lighthouse Commissioners; Messrs. W. Watson and G. B. Thompson, Commissioners of Irish Lights, with Mr. T. Matthews, Mr. D. A. Stevenson, and Mr. W. Douglass, the engineers of the English, Scotch, and Irish Lighthouse Boards respectively. Mr. E. Price Edwards acted as secretary to the conference.

Fire Risks in Electrical Insulation.—In concluding an article on this subject in the *Engineering Magazine*, Mr. F. A. C. Perrine says: "We believe that we may truly say that an installation for the electric lighting of any building may be made perfectly safe as regards fire risks; using the word 'perfectly' in the human sense, for we know nothing connected with either science or our daily lives in which every form of possible accident may be absolutely guarded against. Such a perfect installation we now understand to be one in which the wires have been properly proportioned to carry their normal current without undue heating; where also fuses are placed on all the branches to blow out whenever the current rises dangerously above that normal; and where not only the insulation of the wire is thoroughly waterproof, but where also its supports are of an incombustible waterproof character, and so arranged as to keep the wire [illegible] tact with all combustible materials; and, above [illegible] inspection, cleaning, and testing, the [illegible] in its original character through[illegible] safe, then, good and honest workmanship must be maintained by constant watchfulness, and not by fancied security."

Coating the Hulls of Vessels with Copper.—A method of coating the hulls of vessels with copper electrically has been devised by Mr. Thomas S. Crane, and is being introduced by the Ship Copper Coating Company, of Newark, N.J. The method consists primarily in the use of flexible, shallow, box-shaped baths, open at one side. Each bath contains a copper electrode and the plating solution, the bath being made watertight by suitable flexible packing at the edges. Several of these baths are used in the plating of the vessel when in dry dock or upon the stocks, the cleaning of the hull at any one time being only necessary in the places where the baths are to be applied. The baths, which are made flexible in order to follow the curvature of the vessel, are readily supported against its side, on its bottom, and along its keel and in other difficult situations, by comparatively simple means. The vessel is made the negative pole by connection with an electric generator; the plating-bath furnishes the positive electrode, and the plating of the entire hull is readily accomplished by shifting the baths from the plated to the unplated sections, and slightly overlapping upon the sections already plated so as to form a continuous coating. It has been found that a current rate of 7½ amperes per square foot and a difference of potential of 1½ volts are sufficient to deposit a perfectly uniform, smooth, and adherent coating to the metallic surface of the vessel.

The Allgemeine Elektricitats Gesellschaft.—We have received a copy of the eleventh report of this Company for the year ending June 30 last, and which will be presented at a meeting of the shareholders on the 28th inst. It may be interesting to learn that this Company, the capital of which is £1,000,000, has as general director Mr. E. Rathenau; and on the administrative council, Dr. G. Siemens, of the Deutsche Bank; Mr. Carl Furstenberg, of the Berlin Handels Gesellschaft; and Mr. Arnold von Siemens, of Messrs. Siemens and Halske. The report shows that the net profits for the year 1892-93 amounted to £80,037, as compared with £75,039 in the previous year. The sum of £80,037, added to the profit brought forward from last year, reaches a total of £97,665, out of which a dividend at the rate of 8¼ per cent. is recommended. This absorbs £82,500; the fees of the administrative council, £4,125; fees of the Board, £5,775; allowances to officers and the pension fund, £4,125; and to the benevolent fund, £250, leaving £890 to be carried forward. The Company now have in hand orders to the value of £562,500, as against £512,500 last year, and favourable results are expected for the current year. The report deals fully with the work accomplished by the Company and with the condition of that now being carried out. The Company have constructed since 1891 six electric tramways in Germany, and they have eight additional lines in course of being erected in Germany, Russia, and in Christiania.

Accumulator Traction in New York.—A service of accumulator cars has been in operation on the Second-avenue surface road since last April, the cars being equipped with Waddell-Entz motors and copper-steel alkaline accumulators. The total mileage run to October 15 was 40,000 car miles. The cost for electric power per car mile works out at 9·32 cents, or, say, 4⅔d. The *Electrical Engineer* of New York, in an editorial on the storage battery outlook, remarks that the figure of 9·32 cents, "of course, exceeds that which may be attained with the trolley system, but the cost for the same items of expense when figured on the basis of 18 cars would compare far more favourably with that of the trolley. If in addition we take into

consideration the cost of overhead construction and its maintenance, the high efficiency at which the engines can be operated, and the other advantages accruing from having the entire operating force constantly under the eye of the superintendent, this disparity is still further lessened. The frankness of the Waddell-Entz Company in thus making public figures which could be obtained in no other way is to be most heartily commended, and we sincerely hope that their present successful attempt on the Second-avenue road may be the forerunner of a considerable application of the storage battery to traction work in the United States. It may take some time yet to heal fully the wounds of the past, but with a better understanding of the nature and capabilities of the storage battery, America may yet turn its early storage battery experience to good advantage."

The Electro-Harmonic Society.—The ladies' night will be held next Friday, the 24th inst., in the Banquet-room of the St. James's Hall Restaurant, Regent-street, W., commencing at eight o'clock. The following is the programme: Part I.: Trio, "Ti Prego" (Curschmann), Miss Annie Swinfen, Miss Mary Hay, and Mr. Maldwyn Humphreys; song, "O, Star of Eve" ("Tannhauser"), (Wagner), Mr. Robert Grice; vocal valse, "Il Bacio" (Arditti), Miss Annie Swinfen; pianoforte solo, "Scherzo," B flat minor (Chopin), Mr. Alfred E. Izard; song, "Annabelle Lee" (H. Leslie), Mr. Maldwyn Humphreys; recitation, "Bergliot," with Greig's music (B. Björnsen), Mrs. Turnbull; songs (a) "All Souls' Day" (Edouard Lassen), (b) "The Double Loss" (Meyer-Helmund), Miss Mary Hay; violin duet (unaccompanied) "Serenata" (No. 1) (Viotti), Tempo Giusto—Andante—Andante con Variazioni—Allegretto—Menuetto—Tempo Giusto, MM. T. E. Gatehouse and J. Greebe; humorous sketch, Mr. George Schneider. Part II: Duet, "Flow Gently, Deva" (J. Parry), Messrs. M. Humphreys and R. Grice; song, "I Dream't that I Dwelt" (Balfe), Miss Annie Swinfen; violin solo, "Benedictus" (Dr. A. C. Mackenzie), Mr. T. E. Gatehouse; new song, "Blue-eyed Nancy" (S. Adams), Mr. Robert Grice; original sketch, "Our Waltz" (E. Turnbull), Mrs. Turnbull; new song, "Voices in the Heart" (W. Slaughter), Miss Mary Hay; violin duet, "Double Rondeau" (L. Jansa), MM. T. E. Gatehouse and J. Greebe; song, "The Dream of My Heart" (Bevan), Mr. Maldwyn Humphreys; humorous sketch, Mr. George Schneider.

Thunder and Hail Storms.—At a meeting on Wednesday of the Royal Meteorological Society, Dr. C. Theodore Williams, president, in the chair, Mr. W. Marriott, F.R.Met.Soc., gave an account of the "thunder and hail storms" which occurred over England and the south of Scotland on July 8, 1893. Thunderstorms were very numerous on that day, and in many instances were accompanied by terrific hailstorms and squalls of wind. It was during one of these squalls that a pleasure-boat was capsized off Skegness, 29 persons being drowned. About noon a thunderstorm accompanied by heavy hail and a violent squall of wind passed over Dumfries and along the valley of the Nith. Many of the hailstones measured from 1in. to 1½in. in length. At the same hour a similar storm occurred at Peterborough. From about 2 until 10 p.m. there was a succession of thunderstorms over the north-east of England and south-east of Scotland, and at many places it was reported that the thunderstorms were continuous for nine hours. Two storms were remarkable for the immense hailstones which fell during their prevalence over Harrogate and Richmond in Yorkshire. The hailstones were 4in. and 5in. in circumference, and some as much as 3in. in diameter. Great damage was done by these storms, all windows and glass facing the direction from which the storm came being broken. It is computed that within a radius of five miles of Harrogate not less than 100,000 panes of glass were broken, the extent of the damage being estimated at about £3,000. The thunderstorms in the northern part of the country travelled generally in a north-north-westerly direction, at the rate of about 20 miles an hour. They appear to have taken the path of least resistance, and consequently passed over low ground and along river valleys and the sea coast. Several storms seem to have followed each other along the same track.

Treatment of Cancer by Electricity. In the course of an article in the *Lancet* on "Rodent Cancer and its Treatment by Electricity," Dr. J. Inglis-Parsons, M.R.C.P., states that this disease, better known as rodent ulcer, is one of the forms of malignant disease resembling epithelioma in its minute structure. With regard to treatment, he remarks that two methods have found favour with surgeons—namely, excision by the knife, and destruction by caustics. Electricity, he says, is not only free from the drawbacks incidental to these two methods, but it has other advantages. The electrolytic action prevents any hæmorrhage, so that the operator is able to see exactly how far he has gone, and to avoid any unnecessary destruction of tissue. There is no pain after the electrical application—in fact, for some days after-sensation is quite abolished The amount of destruction can be regulated with the greatest nicety by increasing or diminishing the strength of the current. The cicatrix which follows appears to leave less deformity than when other means have been employed. For an ordinary case one application under an anæsthetic is sufficient, but with a large ulcer two or three may be necessary. Two needles are employed, with a current strength of 200 to 400 milliamperes. The caustic action of both poles is freely used, and the current is constantly alternated with a band commutator. There is no danger in a current of this strength if care is used. There is no shock afterwards, and the patient can even get up the next day in many instances. No rise of temperature takes place if the wound is kept aseptic. The sloughs separate in the course of a week or 10 days, and the ulcer soon heals, leaving a firm cicatrix. Skin grafting is sometimes required. If at any future time a suspicious-looking spot should appear, a short application lasting five or ten minutes will dispose of it. In any case a year or two of immunity can be promised even with a difficult subject.

Electricity in Mining.—Before the Manchester Geological Society, on Tuesday, Mr. W. Saint (president) referred to recent improvements in mining machinery and appliances. He remarked that since the first introduction of electricity as a motive power in mines, improvements had been introduced with a view to prevent the possibility of ignition of explosive mixtures of fire-damp and air, either by sparks from the commutator or an accidental severance of the cables; but even with these precautions it was for engineers to consider whether the cables and motors could be safely placed in position where a naked light could not be used. Its introduction had passed the experimental stage, and there was every possibility that its application would be largely extended. Coal-cutting machines had not been adopted on a large scale in this country, probably owing to the fact that, as a rule, they were only applicable to long-wall working, in which the coal was not usually difficult to get by manual labour. This, however, did not apply to the Stanley heading machine, which had been designed for driving narrow roads. It consisted of a vertical disc, carrying longitudinal cutter bars, which were revolved against the face of the heading by a pair of small vertical engines and powerful gearing worked by compressed air. The bars made an annular

cutting, leaving a central core of coal, which was broken up by wedging and removed by hand. The length of the cut was about 24in., and under favourable conditions the speed of driving was 3ft. to 4ft. per hour. The machine had been thoroughly tested during the past few years, and was a practical success, its chief merit being the increased proportion of large coal obtained from narrow roads and the saving of time in executing a given quantity of work. As to lighting, the president said that nearly all the principal collieries were now provided with installations of the electric light for illuminating the surface works and the main roads, etc., near the bottom of the winding shafts. It compared favourably with coal gas as regards illumination, cost, and immunity from risks by fire.

Fusion and Volatilisation of Metals and Oxides in the Electric Arc.—In the *Compte Rendus* M. Moissan deals with this subject. He states that in order to condense and collect the substances that sublime, a copper U-tube, through which a rapid current of cold water is continually passing, is introduced into the electric furnace immediately above the crucible containing the substance under investigation. Asbestos cardboard placed above the opening through which the U-tube is introduced serves also to condense some of the vapour. When magnesium pyrophosphate is submitted for five minutes to the action of the arc formed by a current of 300 amperes and 65 volts, a sublimate of magnesium oxide and ordinary phosphorous is obtained. Asbestos, with 300 amperes and 75 volts, almost completely volatilises in a few minutes, and leaves only a small residue of the fused silicate, together with a small globule of magnesium silicide. Copper, with 350 amperes and 70 volts, volatilises rapidly, and condenses in globules. The vapour forms cupric oxide in contact with air. Silver readily enters into ebullition, and distils more easily than zirconia or silica. It condenses in fused globules, a grey, amorphous powder, and arborescent fragments. Platinum melts almost immediately, and very soon begins to volatilise, condensing in brilliant globules and also in the form of a powder. Aluminium, with 250 amperes and 70 volts, likewise volatilises, and condenses in small spherules. Tin, with 380 amperes and 80 volts, volatilises readily, and condenses in small globules and in fibrous masses. Gold, with 360 amperes and 70 volts, volatilises to a considerable extent, even in six minutes, and condenses in small spheres. Manganese, with a current of 380 amperes and 80 volts, volatilises very readily; 400 grammes of the metal left only a small residue of the carbide after heating for 10 minutes. Iron, with 350 amperes and 70 volts, volatilises, and condenses as a grey powder mixed with some very brilliant malleable scales. Uranium, with 350 amperes and 75 volts, volatilises readily, and condenses in small non-magnetic spheres, free from carbon. Silicon volatilises with 380 amperes and 80 volts, and condenses in small spheres, mixed with a grey powder and a small quantity of silica. Carbon, with 370 amperes and 80 volts, rapidly changes into graphite and then volatilises, condensing in very light, thin, translucid, maroon-coloured plates, similar to or identical with the maroon-coloured variety of carbon observed by Berthelot. It burns easily in oxygen. Calcium oxide, with 350 amperes and 70 volts, volatilises after eight or ten minutes, and with 400 amperes and 80 volts it volatilises in five minutes. The oxide condenses entirely as an amorphous powder. With 1,000 amperes and 80 volts, 100 grammes of the volatilised oxide can be obtained in five minutes. Magnesium oxide is more difficult to volatilise than calcium oxide, and its boiling point is near its melting point. With 360 amperes and 80 volts, it gives off a quantity of vapour; and with 1,000 amperes and 10 volts, distillation becomes very rapid.

The Chloride Storage Battery.—This battery, of which a description was recently given before the Electrical Section of the Franklin Institute, is so called because the plates constituting the element are made up of tablets cast from fused chlorides of lead and zinc, held together by a frame or rim of antimonious lead. After they are cast, they are reduced so that the lead alone remains in a pure metallic, spongy form. This chemical change is brought about by putting the plate in a bath of chloride of zinc in connection with a slab of metallic zinc which forms a primary battery—the zinc acting as a positive element, while the moulded plate constitutes the negative element. The resulting electro-chemical action causes the withdrawal of the chloride of zinc from the tablets by simple solution in the bath, and the combination of the chlorine of the chloride of lead with the zinc, forming chloride of zinc. Thus the chloride of lead in the tablets constitutes the material which becomes active by electrical disintegration through being connected with the zinc plates in the bath of chloride of zinc. When this reduction is complete, a number of plates is set up as positives in a bath of dilute sulphuric acid, plain lead plates being used as negatives, and a heavy current passed through them for several hours. When the plates are removed from this bath they are next charged continuously in connection with the plain lead permanent negatives for several weeks or until the crystalline lead has been completely converted into peroxide of lead. Positive plates are then set up with the requisite number of negative plates to form cells, which, after being charged a few times, are then ready for shipment. The function of the chloride of zinc in this process is twofold. In the first place, it is impossible to cast plates of chloride of lead without it, as the casting on cooling falls to pieces, so that the admixture of chloride of zinc is absolutely necessary on this account. In the next place, by the use of chloride of zinc it is possible to so control the density of the plate as to produce any desired porosity, and as within certain limits the capacity of a plate is proportional to the porosity, this use of chloride of zinc is of vast importance. In the manufacture of the ordinary red lead or pasted plate, the density of the material depends upon the pressure used in entering the red lead into the grid, and consequently the plates are seldom, if ever, uniform. In the chloride cell, on the other hand, the tablets are absolutely uniform. The mixed chlorides on cooling crystallise into a hard stony substance, and after reduction the metallic lead is left in the form of the needle-shaped crystals running through the plate perpendicularly to the surface; the elimination of the chlorine and zinc provides minute cell-spaces around these crystals, so that an immense surface is offered for the absorption of oxygen in the forming process. The capacity of cells of this type is from five to six ampere-hours per pound of plate, and the discharge rate corresponding to this is one-half an ampere for each pound of plate, a higher rate than recommended for any other lead element. At this rate the watt hour efficiency is from 75 to 85 per cent. Special care is given to the insulation of the plates, it being well known that short-circuiting is one of the main causes of trouble in storage batteries. To overcome this, the positive plate is enveloped in woven asbestos cloth, and between the positive and negative plates is a perforated grooved board of insulating material with perforations which are opposite the pieces of active material in both plates, leaving a free circulation of the electrolyte between the plates and at the same time keeping the asbestos cloth pressed against the face of the positive one, thus holding the peroxide always in position. One of the great advantages claimed for this type of battery is its applicability to cases where there is a large variation in load and consequently in discharge.

ROBERT PERCY SELLON.

Among the electrical engineers who will take front rank during the end of the nineteenth century the subject of our sketch will be prominent. Mr. Sellon was born at Poonah, in the Bombay Presidency, India, in 1863, being the son of the late Colonel Robert Sellon, of the Royal Engineers. He was educated at Blackheath and at Bradfield College, Berks.; and in 1879 was a student at the City and Guilds Technical Institution, passing through the course of electrical technology under Profs. Ayrton and Perry. He served his time in the works of the Anglo-American Brush Electric Light Corporation on their establishment in this country, and joined the technical staff of the company afterwards. In this capacity he had charge of the company's prominent exhibits at the Crystal Palace electrical exhibition of 1882, and was for many years engaged in putting down some of the earliest installations of Brush plant in this country, and was responsible for the lighting of H.M.S. "Colossus," the first man-of-war in the British navy equipped with incandescent lamps throughout, with search-lights actuated from the same dynamos—the course now always adopted. Mr. Percy Sellon has visited all the continents and most of the countries of the world in connection with the Brush Electrical Engineering Company's interests, and their extensive foreign and colonial businesses are largely the result of this work. In 1890 he was appointed assistant manager of the Brush Company; and on the retirement of Mr. Garcke from the managership, Mr. Percy Sellon was appointed joint manager with Mr. J. S. Raworth. Mr. Sellon is a member of the Institution of Electrical Engineers and of the Physical Society.

MOTOR GEARING FOR ELECTRIC TRAMCARS.

(Concluded from page 442.)

The remaining types of toothed gear that have been employed for electric tramway motor work are practically only two in number—viz., worm gear and bevel spur wheels.

The former—used with some amount of success on the Blackpool and Brighton lines, where small powers only enter into account—has had a warm advocate in Mr. Anthony Reckenzaun (whose lamented death is noticed elsewhere in this issue); but even with carefully-designed worms and worm wheel the efficiency of this gear—at a speed, say of 750 revolutions, suitable to tramway work—does not in practice exceed 85 per cent., a result in no way better than that which ought to be obtained with ordinary well cut spur gear. Moreover, it has the disadvantage of requiring the use of a thrust bearing to take the longitudinal strain, from which fact probably arises the low efficiency owing to increased mechanical friction. Then again, if the worm is designed for efficient motion as a driver, it is not suitable for being driven, and, therefore, the gear ought to be cut out of action when the car is going down hill under the action of gravity.

The three advantages of this type of gear are not, however, unimportant: in the first place, it runs with remarkable quietness and ease when kept well lubricated; secondly, it may be covered over and protected from dust or mud with greater ease than any other form of gear; whilst in the third place, the ratio of speed reduction is much higher than with ordinary spur gear, and, therefore, *the motor may be run at a higher* velocity, with perhaps less weight for a given output and efficiency. The ratio of speed reduction in a well-designed worm gear need never be less than, say, 8 to 1, so that a speed of 750 to 800 revolutions per minute is quite easily reached by the motor.

The dimensions of a worm and worm wheel suitable for electric traction work are given as follows by Mr. Reckenzaun:

Worm.	Worm Wheel.
Diameter, 6in.	Diameter, $15\frac{1}{4}$in.
Treble thread, 6in. pitch.	Number of teeth, 24.
Turned out of solid steel.	Cast in phosphor bronze, with cut teeth.

These particulars may be compared with some dimensions of straight-toothed spur gear wheels, as, for instance, the pinions upon armature axles. Such range in size

	Diam.	Width of face.	No. of teeth.	Bore.	Key-way.
From ...	$4\frac{3}{4}$in. ..	$3\frac{1}{4}$in. ...	17 ...	$1\frac{5}{8}$in.	... $\frac{3}{8}$in.
To	$6\frac{3}{4}$in. ...	5in. ..	18 ...	$2\frac{3}{8}$in. and 2in.	... $\frac{5}{8}$in.

An intermediate size of armature pinion, such as would be employed on what is called the W.P. 30 type of Thomson-Houston tramcar motor, measuring $5\frac{1}{2}$in. diameter, $4\frac{1}{2}$in. on face, with 14 teeth, and $2\frac{1}{4}$in. bore, is now being made out of fluid compressed steel. The billet from which it is formed measures in the rough about $7\frac{1}{2}$in. × $3\frac{5}{8}$in., and a hydraulic pressure of 40 tons to the square inch is said to be employed to mould it into the proper shape.

With regard to bevel spur gear, there is not nearly so much to say in its favour. The efficiency seldom, if ever, rises above 80 per cent., whilst the space taken up exceeds that of the worm gear. A recent form of bevel gear employed for traction work had the following dimensions:

Pinion.	Axle Gear Wheel.
Width on face, 5in.	Width on face, $5\frac{1}{2}$in.
Smooth cast steel, teeth uncut.	Double shrouded teeth, uncut. Smooth cast steel.

The only, or chief, advantage afforded by bevel gear is that greater freedom or scope is allowed for suitably placing the motor; and against this must be placed its low efficiency and the mechanical disadvantages of small pinions and weak teeth.

One of the most important questions which have required solution in regard to the mechanical gears for use in electric tramway work has been the problem of double *versus* single reduction of speed. It may be regarded, however, as being by now settled very definitely in favour of a single reduction, and the reasons for this become evident when we consider the greater simplicity and efficiency of the latter. Putting aside all question of the employment of belts, or other friction devices, the real struggle has been fought out between single and double reduction toothed gears. With regard to worms and worm wheels, a single reduction is enough, and the total efficiency of motor and gear combined is in practice, or ought to be, about 77 per cent., allowing 94 per cent. for the motor at 750 revolutions per minute and an average of 82 per cent. for the gear.

With spur wheels, however, the high speed of the early motors rendered necessary at first a double-reduction arrangement, and the combined efficiency of such a motor with two sets of gear seldom or never surpassed 70 per cent., inclusive, that is, of gear and journal losses, as well as those in the motor itself. A single-reduction system, on the other hand, is in poor condition when it cannot show results at least equivalent to those given by worm gear, or, say, 76 per cent. Taking two extreme cases of double and single reduction methods, such as, for instance, that at Bessbrook and the Thomson-Houston modern standard, we have for equal output, say, 20 h.p., the following details:

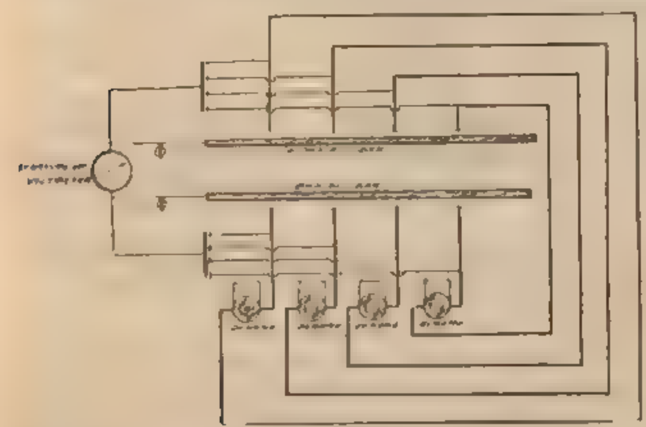
	Speed revs. per minute.	Efficiency.	Weight, cwts., of motor.
Bessbrook......	850	90 per cent.	24
T.-H.............	450	91 per cent.	17

The efficiency of one set of gear wheels probably does not exceed 85 per cent. in practice, so that the combined efficiency of the double-reduction motor and gear averages about 90 × 85 × 85, or, say, 65 per cent. only. The single-reduction motor will, on the other hand, give at least

76 per cent.—that is, 91 × 85. It may be said that the Bessbrook line does not offer a fair sample of double reduction methods since it was a pioneer enterprise, and employed motors not only of a heavier but also of a less efficient type than would now be installed for the same output. So long, however, as the increased efficiency in the high speed motor is only 3 or 4 per cent. at the outside in excess of what can be obtained in machines running at half the speed, the double-reduction system must inevitably give way, if for no other reason than because the efficiency of spur gear does not in practice average more than 85 per cent.; the other types of mechanical connection between motor spindle and car axle are still less efficient, and, therefore, would emphasise the difference. Of course, throughout these remarks the term "efficiency" has been used in connection with motors presumed to run at full load or with maximum efficiency.

POLARITY TEST FOR CENTRAL-STATION USE.

Where shunt dynamos are used in parallel it is very desirable to have some simple and obvious means of testing the polarity of any machine that is to be added to those already on the circuit The diagram given below will explain itself. Most installations have a starting-up voltmeter that may be connected to any individual machine.



All that is required is to connect the positive terminal of starting-up voltmeter to positive omnibus bar through an incandescent lamp, and the negative terminal in a similar way to the negative omnibus bar. Then while the new machine is not excited, and with the starting voltmeter on, each lamp will glow with half the voltage of the circuit, and so present a red light. If the dynamo excites up with right polarity the lamps will gradually be extinguished; on the other hand, if the dynamo be reversed, each lamp will receive its full voltage of 100 volts, and burn normally. With slight and evident alterations, this method may be adapted to places where the three or five wire systems are in use. It should be pointed out that it is advisable that the voltmeter circuit should not be broken unless the brushes of dynamo are down, and that the lamp connections do not affect the voltmeter readings when the voltmeter switches are in. L. LE GROS HORNE.

POLYPHASE ALTERNATE CURRENTS.

M de Chasseloup-Laubat, in the *Compte Rendu* of the Société des Ingénieurs Civils, enters into a long comparison between the distributions by continuous and alternating currents. After alluding to the prominent differences between the two systems as to use of motors in the former and efficiency and simplicity of the latter, he deals with the most frequent and complex case—distribution in towns. Dividing the systems at present employed, we have: (1) alternate currents; (2) continuous currents without accumulators, and (3) continuous currents with accumulators. He deals with each separately, giving diagrams.

1. DISTRIBUTION BY ALTERNATE CURRENTS.

The facility of transformation of these currents permits the use of enormous pressures concentrated on circuits perfectly isolated. A considerable saving in copper is thus assured, while having small line losses. For instance, the dynamo giving 100 volts may have an efficiency of 90 per cent.; this pressure can be raised to 10, 25, or even 30,000 volts in a transformer of 96 to 97 per cent. efficiency—giving a total generator efficiency of 87 per cent. The line loss, with a relatively small section of copper, will be not over 5 per cent. One or several sub-stations will receive this current and reduce the tension to 1,000 or 2,000 volts, with a loss of 3 or 4 per cent. In such a system the transformer load can be kept high, and we have 80 per cent. of the energy delivered at the sub station switchboard The loss in the network will also be small at 1,000 or 2,000 volts without having large sections of copper.

The high efficiency achieved to this point is unfortunately diminished by the house transformers which reduce the pressure to 100 volts. As these hardly ever work at full load, their average efficiency is not much over 50 per cent. Arrangements devised to obviate this loss have not as yet achieved practical success, or at least cause complications which have prevented their adoption.

The daily consumption in towns generally follows a law analogous to that indicated in Fig. 1. As is seen, the total plant is occupied over a very few hours, and the mean specific efficiency (*i.e.*, its utilisation) is very low.

In this class of distribution there is a direct connection between engine and lamp—there is, as one may say, a want of elasticity. As security of working is required, this necessitates spare plant, which again reduces the already low utilisation of the machines.

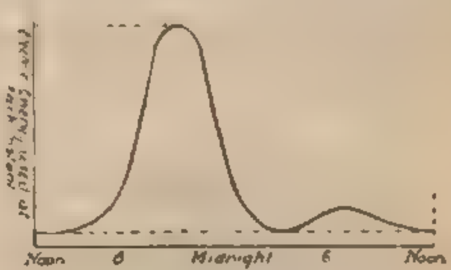


FIG. 1.—Typical Load Diagram.

2. DISTRIBUTION BY CONTINUOUS CURRENTS WITHOUT ACCUMULATORS.

Except for the possibility of using current for electrolytic purposes (a rare occurrence) and especially for driving motors of easy manipulation and high efficiency, this method is not superior to the first. Such high tensions cannot be employed, while the continuous-current transformers having moving parts require constant attention. They must, therefore, be placed in the sub-stations and not in the houses, and from this it results that the distribution must be at 110 volts, or 220 in a three wire system, and that the cost of network will be high—in copper and in loss of energy. What has been said as to low utilisation of plant in the alternate-current distribution applies equally to this system.

3. DISTRIBUTION BY CONTINUOUS CURRENTS WITH ACCUMULATORS.

Although this has been attempted, it does not seem to be practical to use accumulators as transformers. As the total energy must pass through the accumulators there results a total loss of 25 per cent., and at high tensions the insulation of the batteries is difficult to maintain. The batteries must be placed in sub-stations, as they cannot go in the houses. These sub-stations may be either in shunt or in series at high potential. The following are the different arrangements possible to adopt.

(*a*) *Sub-Stations in Series.*—The high-tension current here must be constant in strength; and as the consumption of the different sub-stations is not the same, as soon as one battery is charged it is cut out of the charging circuit to diminish the resistance of this circuit. But the loss in the line, L, is still the same whatever the number of batteries,

and the cutting-out operation is delicate. The distribution, $D^1 D^2 D^3$, may be on two, three, or five wires.

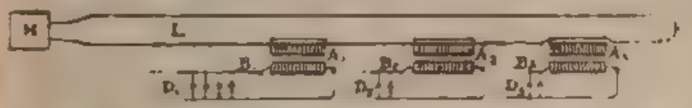


FIG. 2.—M, machine producing high-pressure current. L, line feeding sub-stations. A^1 A^2, batteries being charged. A^3, battery charged. B^1 B^2 B^3, batteries feeding low-tension network (D^1 D^2 D^3.)

(*b*) *Sub-Stations in Parallel.*—This system requires constant pressure in the high-tension wires. The E.M.F. of each battery must be equal to this pressure; during discharge each battery is divided in groups run in parallel. This system led to the use of cells with a large number of small plates, which is inconvenient, and in other respects it seems less practical than the preceding arrangement.

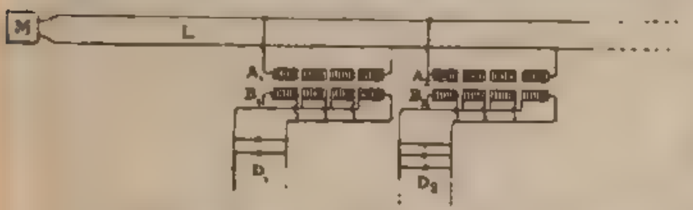


FIG. 3.—M, high-tension machine. L, line supplying sub-stations. A^1 A^2, batteries in charge. B^1 B^2, batteries feeding low-tension networks (D^1 D^2); these batteries are divided in groups coupled in parallel. D^1 D^2 are with two, three, or five wires.

The line loss here diminishes with the diminution of energy supplied. This system has never been employed, at least to the author's knowledge.

(*c*) To avoid the transformation of the totality of that electrical energy and to diminish by half the number of accumulators, the following arrangement has been made:

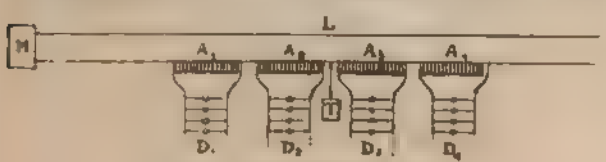


FIG. 4.

The high-tension current passes through the whole of the batteries of the different sub-stations placed in series: the secondary circuits are branched from the terminals of each battery.

The difficulty of insulation—which only exists in systems (*a*) and (*b*) during charge and when there is no communication between battery and secondary circuit—here becomes permanent. Moreover, although the difference of pressure between the two wires is only 100 volts, that between one of the wires and earth may be considerable,

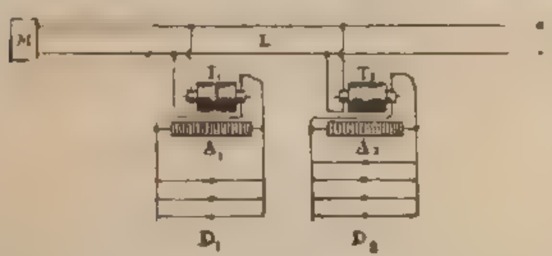


FIG. 5.

and safety to customers is not assured. The maximum difference must not exceed the limit of danger; and this limits the high tension to 400 and 500 volts. In this case recourse is had to the five-wire system. The middle of the circuit, T, can be put to earth, but the insulation is then more difficult, and there is danger of burning up the apparatus.

(*d*) When, for reasons of economy, high-tension circuits must be used, it seems more reasonable to use *continuous-current transformers* in sub-stations with a battery in *parallel to each dynamotor.*

The dynamotors, T_1 T_2, may be placed either in parallel or in series on the high-tension circuit, L. The distribution, as before, can be with two, three, or five wires.

Here, not only are the secondary circuits working at low pressure, but they are at a small difference of potential with the earth. Personal safety and security of plant are both easier to attain.

We can thus employ the highest pressures possible to produce. As, moreover, the efficiency of these machines is over 90 per cent., and only a part of the energy passes into the accumulators, a satisfactory economy is assured.

In any case, whichever of the systems, (*a*), (*b*), (*c*), or (*d*), are used, the utilisation of the plant will be excellent.

As is seen from Fig. 6, the plant can work at full load continuously, or, for instance, 20 hours out of 24. They thus work at their highest efficiency, and are utilised to the maximum.

Sometimes the machines supply direct (or by intermediary of transformers) the electric energy required for distribution at the same time as they charge the cells. Sometimes, on the other hand, the cells come to the aid of the machines by giving back this energy. In case of stoppage the cells will assure service during a certain time, and therefore there need be little spare plant.

The accumulator here plays the part of intermediary, and the system has the required elasticity of which mention has been made.

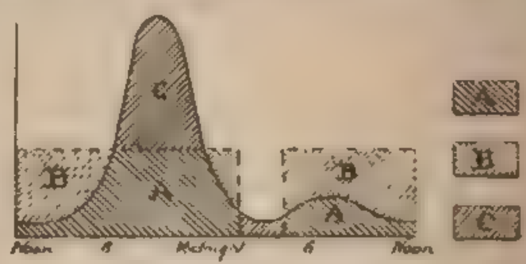


FIG. 6.—A. Electric energy supplied by the machines to the distribution. B. Energy supplied to accumulators. C. Energy given back by the accumulators to the distribution.

CONCLUSIONS.

To sum up, this comparison between alternate and continuous currents shows that:

1. Alternate currents are preferable for long distances, as much on account of the high tensions that can be used as for ease of transformation.

2. In the secondary networks at low tension, continuous currents are superior because they allow the use of accumulators, whence results a better utilisation of plant and greater security of working.

This leads to the expression of three desiderata:

I. To store electric energy supplied in the form of alternate currents.

II. To transform alternate into continuous currents.

III. To transform the energy supplied by alternate currents into mechanical work.

It may be remarked that the solution of problem III. involves the solution of II., as an alternate-current motor could drive a continuous current. So, also, the solution of II. affords a solution to I. by the transformation into continuous current and the storage of the energy of this latter.

Nevertheless, we preserve the original form to these three desiderata, not to prejudice their direct solution.

I. Speaking commercially, the first desideratum does not seem to include the direct solution for the moment.

II. MM. Hutin and Leblanc have been long occupied with the possibility of accomplishing this direct transformation, and have published very interesting articles thereon. Quite lately they have set forth a general method for transforming alternate into direct currents. This method seems now quite practical and particularly convenient in the case of employment of polyphase currents.

We shall study later the different methods of transformation of these currents.

This problem, being solved practically, enables us to adopt the mode of distribution shown in Fig. 7.

An alternator first produces polyphase currents at low pressure (triphase, for instance).

A transformer raises this to 10,000 or 15,000 volts, at which it is transmitted to the distant point. The current is then let down to 2,000 volts by a transformer and distributed to sub-stations, which can be placed in series or in parallel. In the sub-stations are placed the special apparatus mentioned to transform these polyphase into continuous currents; and further, a battery of accumulators is placed in parallel with these latter machines.

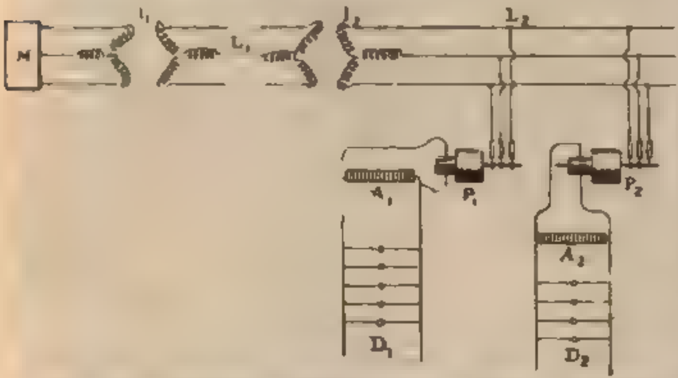


FIG. 7.—M, polyphase generator of low tension. T_1, step-up transformer. L_1 long-distance transmission. T_2, step-down transformer. L_2, circuit feeding sub stations. P_1 P_2, transformers in sub stations transforming polyphase currents of high tension into low tension continuous currents. A_1 A_2, accumulators in parallel. D_1 D_2, distribution at low pressure, continuous current (two, three, or five wires).

It seems preferable to place the sub-stations in parallel rather than in series, because of the independence of each other thus realised. If the polyphase transformers, P_1 P_2, included an exciting circuit requiring continuous current, this could be obtained from accumulators.

The advantages of all the methods of distribution hitherto described are united in the above system.

The alternator and the different transformers work at full load, and consequently at maximum efficiency and utilisation. The security of working is great, owing to the use of accumulators. The transmission to long distance is not too onerous, owing to the high tension employed. Lastly, the security to person is safeguarded, as the conductors accessible to the consumer are all at low tension.

(To be continued.)

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE IV.

(Concluded from page 450.)

The High Pressure Reservoir at Bessinges.—When the high-pressure system was first put in operation a constant pressure was maintained in the mains by constantly pumping in excess of the demand, and allowing the surplus to flow away through a relief valve. This involves a constant waste. To further moderate fluctuations of pressure, four large air vessels (additional to those at the pumps) were erected. These were 5ft. in diameter and 39ft. high, and were kept charged with air by a Colladon compressor. When it became a question of driving the electric station by turbines driven by water from the high pressure system, the need of a storage reservoir became pressing. At four kilometres from Geneva a site was found, at an elevation of 390ft. above the lake, and it was decided to construct a reservoir capable of storing the discharge of three groups of pumps working through the night. The discharge of the pumps is 34,000 cubic feet per hour, or 442,000 cubic feet per 13 hours, during which, if there were no means of storage, they would be put out of action.

The reservoir is a covered reservoir, capable of containing 453,000 cubic feet. It stores, therefore, 5,573 gross horse-power hours of energy. Allowing for the loss at the motors driven by the pressure water, the reservoir will furnish about 800 effective horse-power for five hours. It serves as a perfect regulator of pressure. A float with electric signal and recording apparatus shows constantly in the pump-house the condition of the reservoir.

Hydraulic Pressure Relay or Compensating Pressure Regulator.—The 18in. pipe main from the pumping station to the reservoir at Bessinges being four kilometres in length, there would be a difference of pressure in the mains in Geneva equivalent to the friction of eight kilometres of main, according as water was being pumped up to or flowing back from the reservoir. This would not have been very serious if all the motors driven by the water had been supplied by meter. But the larger motors are supplied by gauging, the quantity of water used being computed from the area of the orifices of discharge. Variations of head would have involved a variation of the quantity of power developed at the motors amounting to 20 per cent. This would have hindered the development of that method of estimating the charge for water.

To prevent this variation of head, Colonel Turrettini devised a centrifugal pump relay, shown diagrammatically in Fig. 22, which comes into action automatically, and increases the pressure whenever the water is returning from the reservoir to the town. The centrifugal pump, which forms part of the main, is driven by a turbine so regulated for speed that a constant pressure is obtained on the town side of the pump. The pump receives at the maximum 635 cubic feet of water per minute, and can give to the stream passing through it an increase of pressure of 30ft. The turbine works with 380ft. of head, and can exert 120 h.p.

The sluices of the turbine are governed by an automatic pressure regulator. The pressure in the main acts on a piston controlled by a spring. According to the position of the piston, the turbine sluices are open more or less. The movement of the piston actuates the valve of an hydraulic relay which operates the turbine sluices. During the filling of the reservoir the centrifugal pump is at rest, the water merely flowing through it. When water flows back from the reservoir the turbine begins to drive the pump so as to increase the pressure in the main. The arrangement has worked with perfect success.

The Motors Used in Geneva.—The original motors used in Geneva were Schmid pressure engines, and these are still used for small powers. They use a quantity of water which depends on the speed only and not on the work done. Hence they are uneconomical with light loads. They are convenient and cheap, they can be run at any speed, and they act as meters of the quantity of water used. A counter on the pressure engine recording the number of revolutions, gives the means of ascertaining accurately the quantity of water used. At full load their efficiency is 80 per cent.

For all larger motors impulse turbines are used. The maximum efficiency of these is 75 per cent., and it is not much less with light loads. They occupy little space, and can be perfectly governed to constant speed by the ingenious relay governors of Messrs. Faesch and Piccard. In Geneva the question of speed regulation was found to be an important one. The industries connected with watchmaking required motors running at constant speed.

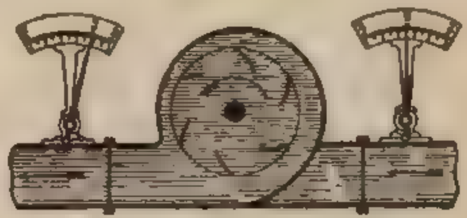


FIG. 22.

The Electric Lighting Station.—In 1887 the City Council came to an arrangement with a company for supplying electricity. It was part of the arrangement that the company should use pressure-water, supplied by the town, as motive power in all its installations. The pressure-water is supplied to the company by meter, at a price of two centimes per metre cube, with a minimum of 40,000 cubic metres annually. This is equivalent to a little more than £3 per effective horse-power per annum. The advantage to the town is that their pumping machinery can be run constantly, night and day, the energy, which would otherwise be wasted, being stored. The electric company, on the other hand, got power at a cheap rate, and their turbines being driven by high pressure are convenient and cheap, and run at an extremely constant speed.

Under the arrangement an electric station has been installed in the old pumping station, no longer required for its original purpose (see Fig. 21). There are three impulse turbines of 200 h.p. each, and each turbine drives two dynamos directly coupled to it by Raffard couplings. There is also a 25 h.p. turbine and dynamo for day work. It is the system of reservoir storage which makes this hydraulic driving of the dynamos possible and economical. They could not be driven so conveniently by the large low-pressure turbines in the river, with the very varying head which they have to utilise, nor could power be spared to drive them, except by utilising the motive power of the flow of the river through the night.

LECTURE V.

TRANSMISSION BY COMPRESSED AIR.

Compressed air has been employed in engineering operations for a long period. The earliest important application was the diving bell. This is believed to have been used in the sixteenth century. Smeaton, in 1788, and Rennie, in 1812, used diving bells and air compressors in important operations. Subsequently, compressed air was applied in sinking bridge piers. Cubitt employed compressed air in sinking the piers of Rochester Bridge, in 1851; and Brunel a similar process at Saltash in 1854. Compressed air was applied in driving the Thames Tunnel by Brunel and in driving the Thames Subway, by Barlow. It has been used

* Howard Lectures delivered before the Society of Arts.

since in several similar works of a difficult character. The shaft of the Marie Colliery, at Seraing, was sunk by means of compressed air, by the firm of John Cockerill, in 1856.

The application of compressed air as a motive power in transporting goods seems to have been first suggested by Medhurst, in 1810, and by Vallance, in 1818. Some early pneumatic railways were built; later, similar methods have been revived in the systems for transmitting messages and parcels through pneumatic tubes in London and Berlin.

Papin appears to have considered the transmission of motive power to a distance by a vacuum method in 1688. Triger actually transmitted motive power by compressed air a distance of 750ft. at the mines of Chalonnes in 1845. Soon after, compressed air was used in several collieries. The greatest impetus to the application of compressed air as a means of distributing power resulted from its employment in working boring machinery in tunnels. Brunton, in 1844, suggested this application, and, in 1852 Prof. Colladon, of Geneva, proposed the use of compressed air in the construction of the Mont Cenis Tunnel. It was, perhaps, at Mont Cenis that compressed air was first used for motive power purposes on a large scale. M. Sommeiller, in association with M. Kraft, made extensive experiments at the works of John Cockerill at Seraing, and with the data so obtained the whole of the machinery for compressing, transmitting, and utilising compressed air at Mont Cenis was designed and constructed at Seraing. At first, for compression, a kind of hydraulic pneumatic ram was used. In 1861 this was superseded by water piston compressors, driven by turbines. The air was transmitted a maximum distance of 20,000ft. to work the drills. The air pressure used was seven atmospheres (105lb. per square inch). There were at Mont Cenis air motors worked expansively, the cylinders of which were heated externally to prevent freezing. In the construction of the St. Gothard Tunnel, in 1872, still more powerful air-compressing machinery was employed. The compressors were at first designed to be of small size, to run at a high speed, and to be cooled externally; but with a short stroke and quick speed there is not time for the heat developed by compression to be abstracted through the cylinder wall, and a spray injection, suggested by Prof. Colladon, was added.

In 1887, Mekarski used air compressed to 25 or 30 atmospheres, in conjunction with a small amount of high pressure steam, to drive tramway cars, and he was one of the first to use compound compressors.

In 1877, at Vienna, and in 1881, at Paris, M. Popp installed a system for working and regulating a great number of clocks by impulses of compressed air conveyed in pipes from a central station. A demand arose for a supply of the compressed air for working small motors, and this proved so successful that there has been developed in Paris the most important system of power distribution hitherto carried out. In Paris, motive power is transmitted to industries of every kind over a large area by air compressed at a central station, and even sub-stations for electric lighting are driven by air motors. It is interesting that in Paris a system of distributing motive power by vacuum carried out by M. Boudenoot, has been successfully in operation since 1885. The motors are worked by atmospheric pressure and exhaust into pipes, in which a vacuum is maintained by air pumps at a central station. A system of pumping sewage at a number of scattered sub-stations by compressed air supplied from a single compressing station has been developed by Mr. Isaac Shone, and is in operation at several towns in this country and the United States, and at Rangoon.

Compressed air transmission is a perfectly general method of distributing power for all purposes. Whether, in any given case, it is the most advantageous, the least wasteful of power, or the cheapest in working cost, depends on various circumstances. M. Hanarte believes that it is—and will continue to be—the most economical method of transmission to considerable distances.* The loss in the air mains is very small. The motors worked expansively are efficient. The mains can be carried by any path, and differences of elevation between the compressing and working points do not sensibly affect the result. In hydraulic transmission the water must be collected, stored, and in some cases filtered; and having actuated a motor, means must be found for removing it. But air is everywhere available, and can be discharged anywhere without causing trouble. Compressed air has peculiar advantages in the case of underground transmissions. It has been used to replace manual labour in situations where hardly any other motive power could have been employed. In driving a tunnel at a mine at Sacramento, for instance, the cost was reduced to one-half, and the rate of boring was three times as fast when compressed air machinery replaced hand labour. In such cases the advantage is so great, even with uneconomical machinery, that the inducement to adopt very perfect machinery is absent. Hence, much of the air compressing plant at mines has been unnecessarily inefficient and wasteful of power. In many cases, air compressing plant has been driven by water power, and this also has tended to a neglect of the conditions necessary for economical working. Mr. Savage argues, with reference to the Terni Steelworks,† that the common objection to the use of compressed air on the ground of waste of power, loses much of its force when the compressors are worked by an almost costly supply of natural energy such as water power. It is unfortunate for the reputation of the system of transmission by compressed air that the rough purposes to which it has been applied, the indifference to waste of power in mining and tunnelling operations, and the preference for simple and cheap machines, has delayed and hindered the improvement of compressed air plant.

A good deal was done to improve air-compressors by Sommeiller, by Dubois, and François, and by others in the large plants constructed for Mont Cenis, for the St. Gothard works, and for some collieries. In the distribution of power in towns still further consideration has been given to the question of economy of working. But here again it has been very unfortunate that in both the great installations in Paris and in Birmingham, there were conditions of development very unfavourable to the complete and fair trial of compressed air as a means of transmission. It is reasonably certain that with greater attention to scientific principles better results are attainable than have hitherto been reached in the use of compressed air.

For the special purposes to which power distribution is applied in London, the high pressure hydraulic system has great advantages. Where local conditions permit the construction of high level reservoirs, a system like that in Zurich and Geneva of hydraulic distribution is perfectly successful; but in more numerous cases, compressed air is likely to prove preferable to hydraulic transmission. It is also the most important rival of electrical distribution. There are at present extremely few cases where electrical distribution of power has been carried out; and though enough is known of the capabilities of electrical transmission to show that it could be adopted on a large scale with complete mechanical success, the cost of the distribution of power by electrical methods is at present very imperfectly determined. For long distance transmission, and where cheap overhead conductors can be adopted, no doubt electrical methods have an important field of application; but up to the present time, and excluding transmissions for lighting, an enormously greater amount of power has been actually distributed by compressed air than by electricity. So far as can be judged at present, in the case of distribution of power in towns, and especially where work has previously been done by steam-engines which can be converted into air motors, in such cases compressed air is likely to prove a more convenient and cheaper means of power distribution than electricity.

General Considerations on Compressed Air as a Means of Distributing Power in Towns. The desiderata in a system of power distribution in towns may be shortly enumerated as follows: (1) The possibility of indefinitely subdividing the power distributed and measuring the supply to each consumer. (2) Minimum first cost of distributing mains, and minimum loss of energy in distribution. (3) Simplicity, cheapness, and efficiency of the motors required by consumers of power; and, especially, it is important that the motors should require little attendance and involve little risk. (4) Freedom from danger to life or property when accidents occur to motors or distributing mains. (5) Facility of adaptation to various requirements additional to the supply of motive power. This is important, both from the additional revenue obtained, and because the more various the applications satisfied the better are the conditions of working at the central station. The fluctuations of demand are diminished and the load line improved.

A compressed-air system meets these conditions on the whole more completely than any other system hitherto carried out. Experience in Paris shows how great the facility is for subdividing the power in a compressed air system. There are motors ranging from 150 h.p. to less than $\frac{1}{12}$ h.p. (45 foot pounds per second). The majority of the air motors are, in fact, of less than 1 h.p. These can be started and stopped by merely opening or closing the supply valve, and the measurement of the air used presents no practical difficulty. In Paris and in Birmingham the air is measured by meters, which are not costly, and which are accurate enough to give satisfaction. As to the distributing mains, it may be pointed out that in an air system no return main is required, the air being discharged at the working point without creating any nuisance. In a steam distribution a return main is desirable to avoid heat loss, and in an electric distribution a return main is necessary. Air mains are less costly than hydraulic mains or steam mains. Under what conditions they are less costly than electric mains is a question yet to be determined. Probably they are much less costly than electric mains, except in cases where high electric pressure can be used and overhead conductors. M. Solignac has considered the case of the transmission of the 70,000 h.p. from Billancourt to the Place de la Concorde, at Paris, a distance of 4½ miles.* He comes to the conclusion that air mains would cost £112,000, while electric mains, worked at 2,000 volts, would cost £700,000. Even if the energy were required at the terminus in the form of electricity, he concludes that it would cost 20 per cent. less to transmit by compressed air, and generate electricity at the terminus by dynamos driven by air motors than to generate and transmit the electricity from Billancourt. As to loss of energy in the mains, electricity has little advantage over compressed air. The pressure loss in the mains of a town distribution is insignificant. In the Paris system the principal mains have an extension of 35,000 metres (34 miles). The loss of pressure between St. Fargeau and the most distant point of the main rarely reaches 5lb. per square inch. The safety of an air main is obvious, and even a leakage or burst of the main is much less serious, and attended with less damage than that of a water or a steam main. Air leakage is less dangerous than electric leakage. When an air distribution is introduced in a town, power users do not require new plant and need incur no outlay for motors. The boilers—with all their attendant disadvantages of stoking, removal of ashes, cleaning, and risk of explosion—are dispensed with, and the steam-engine, with little alteration, serves as an air motor. If an

* "Transmission du travail a distance, par l'air comprimé." Congress International de Mecanique Appliquée, Paris, 1893.

† *Terni Steelworks.* Savage, *Proceedings* Institution Civil Engineers, vol. xciii.

* Solignac. "Transport de l'energie par l'air comprimé." Congress International de Mecanique Appliquée, Paris, 1893.

electric system is introduced the old motors must be removed and new motors purchased. Further, if electric motors are themselves of high efficiency, they run at a high speed, and in most cases there is a considerable loss in the gearing required to adapt them to ordinary purposes. For small power users there are rotary motors of simple and cheap construction. Lastly, air motors are so simple that they require when working extremely little attention.

In regard to adaptability to various requirements, compressed air is in a very advantageous position. Electricity supplies power and light, but it cannot be used for supplying heat except at a cost prohibitive in most applications. Gas supplies heat, and power, and light; but for lighting it is open to obvious objections, and for heating and power it is expensive. Pressure-water supplies power and, indirectly, light, if a motor is used to drive a dynamo; but, except where cheap water power is the original source of energy, it is too expensive for most purposes where motive power is required. Steam supplies heat, motive power, and, indirectly, light, if a steam motor is used to drive a dynamo; but it is more expensive than compressed air, and involves more risk and attention.

Compressed air can be supplied so cheaply, that not only can it be used directly as a source of motive power, where that is the commodity required, but it can be advantageously used to drive sub-stations and private installations for generating electricity, for lighting purposes, or for working pumps and ventilating fans. With a water cushion between the air and the lift ram, compressed air is as convenient for working lifts as pressure water. It has been used in working cranes at the Cockerill Works for 20 years. Compressed air is not directly a source of heat, but used for blowing purposes it is an extremely useful adjunct to furnaces. In Birmingham, smiths' fires and cupolas have been worked direct from the air mains without any blowing machinery. A small jet of high-pressure air induces a large stream at lower pressure. In Paris, compressed air has important applications for refrigerating purposes. Besides large refrigerating stores in some restaurants, an air motor is used for driving a dynamo for lighting purposes, and the cooled exhaust from the air motor is used to cool chambers in which food is stored. Lastly, compressed air is already used in working tramways, and it appears likely that much larger applications of this kind are possible.

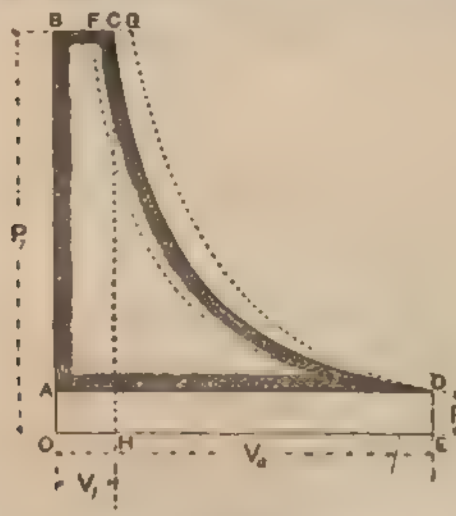


FIG. 23.

General Arrangements of a System of Compressed-Air Transmission.—The arrangements include: (1) A compressing plant driven by steam or water power with air reservoirs of more or less capacity to diminish momentary fluctuations of pressure. The compressors usually require the addition of cooling arrangements for absorbing the heat developed in compression. (2) A system of air mains for distributing the compressed air to the working points. (3) Air motors driven by the compressed air and sometimes provided with reheaters to increase the work done by the air and diminish the cooling during expansion. It is necessary therefore to consider the construction of compressors and their efficiency; the construction of mains and the losses in transmission; and the construction of air motors and their efficiency.

Action in a Compressor.—Consider, for simplicity, a compressor which receives and discharges 1lb. of air per stroke, and let Fig. 23 be its indicator diagram. Let P_a, V_a, T_a be the pressure in pounds per square foot, volume in cubic feet per pound, and absolute temperature of the atmospheric air to be compressed; P_1, V_1, T_1, the corresponding quantities for the air after compression. The quantity $R = V_a/V_1$ is called the ratio of compression.

The compressor in the suction stroke draws in a volume, V_a, of air at the pressure P_a, compresses it according to some law expressed by the compression curve, DC, to the volume V_1 and pressure P_1, and finally expels it into the mains. In general, the compression curve, DC, will be between two curves, DF, DG, corresponding to two limiting cases. If heat is abstracted from the air during compression, so that the temperature remains constant, the compression curve will be the isothermal, DF, defined by the relation—

$$P\,V = \text{constant}.$$

If no heat is added or subtracted during compression, the temperature of the air will rise, and the compression curve will be the adiabatic, DG, defined by the relation—

$$P\,V^{\gamma} = \text{constant}.$$

In ordinary compressors the compression curve lies between DF and DG, and the temperature of the air after compression T_1 will be greater than the initial temperature T_a.

If the compressed air were used in a motor directly adjacent to the compressor in its heated state, there would be no necessary loss due to heating during compression. But commonly the air is used at a distance, and has cooled from the volume BC to the volume BF, and from the temperature T_1 to the temperature T_a before it reaches the working point. The most economical compression therefore for a system of compressed-air transmission would be isothermal compression. The area FDC represents work expended in the compression in heating the air which is wasted before the air is used.

It can be shown that the work wasted in heating the air in the compressor above its initial temperature when the expansion curve is given by the relation—

$$P\,V^{n} \text{ constant},$$

is given by the expression:

$$27{,}710\left\{\frac{n}{n-1}\left[\left(\frac{P_1}{P_a}\right)^{\frac{n-1}{n}}-1\right]-\log_e\frac{P_1}{P_a}\right\}$$

which gives the work wasted in foot-pounds per pound of air.

WORK LOST DUE TO HEATING IN COMPRESSOR.

$\frac{P_1}{P_a}$	P_1 = pressure of compression in lbs. per square in. (absolute).	Work lost in adiabatic compression $n = 1{\cdot}41$.	Work lost in partially cooled compression $n = 1{\cdot}25$.
2	29·4	0·077 $P_a V_a$	0·052 $P_a V_a$
4	58·8	0·322 ,,	0·209 ,,
6	88·2	0·562 ,,	0·363 ,,

It will be seen that the loss increases rapidly, almost as the square of P_1/P_a. This rapid increase of the heating loss has led

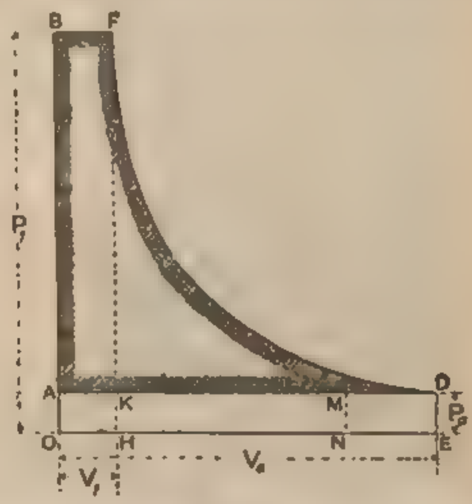


FIG. 24.

many constructors to advise the use of very low working pressures in compressed air transmissions. But that involves an oversight. The increased loss at the compressor, due to a higher working pressure is partly balanced by an increased efficiency of the air motor, so that low working pressures are not necessarily most economical for the whole system.

Case of Isothermal Compression.—The most economical compressor, mechanically, would be one in which the air was compressed isothermally, heat being abstracted during the compression, so that the temperature did not rise. In that case, the heat abstracted is exactly equal to the work done during compression.

The whole work, in a complete double stroke, consists of three parts: (1) The work, OADE, of the atmosphere on the piston during the suction stroke; (2) the absolute work of compression, EDFH; (3) the work of expulsion of the air into the mains, OBFH. In isothermal compression, PV = constant. The effective work expended in driving the compressor, given by the shaded area, ABFD, is the algebraic sum of the three quantities of work just stated. That is

$$-P_a V_a + P_a V_a \log_e\frac{P_1}{P_a} + P_1 V_1 = P_a V_a \log_e\frac{P_1}{P_a},$$

or exactly equal to the absolute work of compression, HFDE. But the heat abstracted during compression is also exactly equal to the area HFDE. Hence the curious result is arrived at that, in the most economical compression, the effective work of compression is entirely abstracted as heat, and wasted. All that the compression has done has been to put the air in a condition to do work in a motor at the expense of its intrinsic energy. The work in the motor is in no sense a return of the work expended in the compressor. Hence the conditions of transmission of power by compressed air are entirely different from those of transmission by pressure-water.

(To be continued.)

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AT THE INSTITUTION.

The winter session of the Institution of Electrical Engineers was inaugurated last week with a lengthy paper by Prof. Forbes, F.R.S., on the subject of electric transmission at Niagara. Before alluding to the general value of the paper there is one question, which on this side of the Atlantic is felt to be a sore one, that may be mentioned. It will be remembered that the company requested certain designs and plans from electrical engineers. The latter readily complied with the request, and undoubtedly a large amount of time, of trouble, and of money was spent in preparing these plans. On consideration, however, of the plans it was found that tariffs interfered with the acceptance of any European design, and so they were thrown aside. The authors received nothing, and have felt that they were badly treated. Some have gone so far as to say the request was issued with an ulterior motive, which, in plain words, was to pick the brains of the world at no cost to the promoters. Prof. Forbes emphatically disclaims any use of the designs sent in so far as the construction of the machines is concerned, and explains in what particulars his design differs from all others. No one for a moment ascribes blame to Prof. Forbes, but the request of the American promoters, on the face of subsequent actions, is not one that can be commended. Prof. Forbes is wise in taking the profession into his confidence, as even during the progress of the work valuable suggestions may be made and tried. The work at Niagara is what Prof. Forbes claims, as important as any engineering work ever undertaken. The utilisation of the waste power at Niagara has been the dream of engineers, and ever since the rise of electrical engineering it has been more prominent, because such authorities as Lord Kelvin, Profs. Ayrton and Perry, etc., early saw the possibilities of power transmission. Prof. Forbes has thrown himself into this work *con amore*, and if success is achieved it cannot for a moment be said it is undeserved. The work is on a grand scale, yet every detail seems to have been carefully examined, not only to see that the purpose required would be effected, but also that the maintenance should be a minimum. Unfortunately, the full proofs of this paper were only distributed while the technical papers were going to press, so that anything like a well-considered opinion is at the moment impossible. The general scope only of the paper can be considered. The author points out he early came to the conclusion that the alternate-current system of transmission was the correct one in this instance, and that the objection to lack of motors has been met by a host of inventions. The critical point, according to Prof. Forbes, lies in the frequency. His investigation led him to the conclusion that the gain is far in excess of the extra cost, and that parallel working is assisted by lowering the frequency, as is the performance of synchronising and other motors. The apparatus at Niagara Falls considered by Prof. Forbes to be the most favourable—hence its adoption by him—is sixteen and two-third periods per second. A large part of the paper is devoted to the consideration of this question,

and will undoubtedly form admirable reading. It does not say much for American constructors to find they decline to construct machines to give above two thousand five hundred volts, and that, therefore, dynamos are to be used generating at two thousand volts, with step-up transformers for the extra high pressure. Prof. Forbes disclaims the obtaining of suggestions from the dynamo designs sent in, and, as previously stated, we do not dispute his disclaimer. We have given concreteness to the remarks flying about, and admitting the absolute accuracy of Prof. Forbes's statement, that does not exonerate the company in its getting plans from Europe. The question of tariff might have been considered in the first place, and the results of the tariffs on cost ought to have been known, so as to save the time, trouble, and expense of those who sent in plans.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE BIRMINGHAM ELECTRIC CARS.

SIR,—From a letter of the Electrical Power Storage Company, it would appear that out of the number of E.P.S. batteries supplied to the Birmingham Central Tramways Company about two years ago two have been regularly working till now, and giving excellent results. This is not according to facts.

On the other hand, the results which have from time to time been published by the Epstein Electric Accumulator Company, Limited, are based on indisputable facts, and their correctness can be easily ascertained. The statements as to the lifetime, reliability, and absence of repairs and renewals were made publicly and confirmed by those best able to judge, being in possession of official figures.

The experience and responsibility of the gentlemen who are entrusted with the management of the affairs of the Birmingham Central Tramways Company should offer a sufficient guarantee that the order given to the Electrical Power Storage Company is coupled with a maintenance clause, and it would be doubting their business capacity if one presumed that the terms of the contract are not more to the interest of the shareholders than the offer made by the undersigned company to work the line and defray all expenses with the exception of permanent way and general charges for 70 per cent. of the gross receipts.

But electrical and tramway engineers would no doubt feel greatly obliged if the information regarding the lifetime, repairs, and renewals of the accumulators, and the financial results to the supplying and maintaining company, were officially vouchsafed from time to time.—Yours, etc.,

L. EPSTEIN, Managing Director.

The Epstein Electric Accumulator Company, Limited.
21A, Blythe-road, West Kensington, Nov 15.

OBITUARY.

THE LATE ANTHONY RECKENZAUN.

It is with the deepest regret that we have to record the death of Mr. Anthony Reckenzaun, which took place early on Saturday, November 11. The death of Mr. Reckenzaun leaves a gap in the professional ranks of the industry which it will be difficult to fill. He had made himself the English authority on all matters relating to electric traction. A brief account of his career appeared in our issue of January 15 last year, which, with the accompanying portrait, we now reproduce. He was born at Gratz in 1852, and received his early education in that town. Like most successful electrical engineers, Mr. Reckenzaun was originally trained as a mechanical engineer. Coming to England in 1872, he entered the employ of Messrs. Ravenhill and Miller, afterwards Messrs. Easton and Anderson. While with Messrs. Easton and Anderson he qualified as a teacher under the Science and Art Department, and established evening classes for the employés. Subsequently he attended lectures at the School of Mines, and at Finsbury. Feeling a great interest in electrical matters, Mr. Reckenzaun made a thorough study of the apparatus at the Paris Exhibition in 1881, then joined the Faure Company, but soon after accepted the position of electrical engineer to the Electrical Power Storage Company. Here he turned his attention to traction, a branch of the industry with which his name has since been intimately connected. Storage batteries were also carefully studied, and their capabilities investigated. In fact, Mr. Reckenzaun perhaps did more than anyone to show, by his practical work, and by various papers, the value of storage batteries in all kinds of electrical work. He spent a year or so in America successfully fighting the fight of such batteries. More recently he has been closely allied with the General Electric Company and with Messrs. Greenwood and Batley. Mr. Reckenzaun reached his acknowledged position as one of our foremost experts in batteries and traction because of the painstaking industry and skill with which he investigates every problem connected therewith. Some months since, the lung troubles to which he finally succumbed were felt to be serious; but although then seriously ill, he during the late summer visited America, hoping the change would prove beneficial, as well as desirous of continuing those business relations which he had on that side

ANTHONY RECKENZAUN.

as well as on this side of the Atlantic. Unfortunately, the hoped-for improvement did not come, and on his return he gradually declined, though hopeful to almost the last. To most of us the loss of this prominent member of the industry means the loss of a personal friend whom we all esteemed, and who was as firm in his friendship as he was able and energetic in his occupation. As will be seen, Mr. Reckenzaun had been engaged in the industry from its rise in 1881, and throughout this period had made a reputation in his particular sphere second to none. His lectures on electric traction to the City Guilds formed the basis of a book on the subject, in which his great knowledge of the subject is fully shown. Yesterday his mortal remains were consigned to their last resting-place in the presence of numerous friends.

REVIEWS.

A Manual of Telephony. By W. H. PREECE, F.R.S., and A. J. STUBBS. Whittaker and Co., London.

This is practically a second edition of "The Telephone" by Preece and Maier, published in 1888, although in consequence of the change in the co-authorship it has been deemed desirable to issue the work as a new one. Mr. Stubbs is a well-known member of the Post Office technical staff, and in securing his collaboration Mr. Preece has been distinctly fortunate. Not only has the subject matter been more judiciously selected, but the book bears the impress

of careful editing, and lacks the numerous errors and bêtises which disfigured the old one and discounted its claim to acceptance as an authority on the telephone and its practical applications. The general plan, however, has not been changed nor has the scope been extended, nor the limits amplified. The alterations consist chiefly in the suppression of the long descriptions of German and French apparatus which constituted a feature of the older book, and which never possessed any value for the telephonist in this country, and the substitution therefor of minute explanations of the most recent improvements in switching apparatus. Thus, not only are the latest American plans, as represented by the Western Electric Company, minutely explained and liberally illustrated, but the switching apparatus designed by Mr. A. R. Bennett for the New Telephone Company, and which recently formed a subject of controversy in the electrotechnical Press, is for the first time described in print. An interesting feature of Mr. Bennett's system is the special form of induction coil used in subscribers' instruments for the purpose of ensuring a perfect balance in the metallic loop under all circumstances. Ordinarily it frequently happens that when two subscribers lift off their phones to speak, the two receivers are in one side of the loop and the secondaries of the induction coils in the other, the phones thus being placed between branches of unequal resistance. The perfect silence aimed at by the use of metallic circuits is lost under such conditions. In Mr. Bennett's coil the secondary is divided into two halves of equal resistance with the receiver connected between them, so securing a permanently perfect balance so far as the instrument is concerned. Mr. Preece, it is to be noted, sticks to his guns manfully on the subject of his K R law, and allows neither the papers of Oliver Heaviside nor the scepticism of many practical telephonists to prevail against him. The work is well and profusely illustrated, the cuts being for the most part prepared from special drawings. Altogether, the new book may be welcomed as the most complete epitome of present-day telephonic practice yet published.

Electric Lighting and Power Distribution. Part III. With 70 illustrations and index. By W. P. Maycock, M.I.E.E. Whittaker and Co.

This third part completes the book. The first portion of this part, though Chapter XII. of the book, discusses principally secondary batteries. A brief history of what may be termed electro chemistry is given, reference being made to Faraday, Grotthuss, Clausius, among the scientific investigators, and to Planté and his successors among those who applied the principles evolved by their predecessors. This information is not very important, but it is followed by an excellent description of a simple battery installation, the illustration to which is worth all the history put together. This is the kind of matter students want—it teaches something new to them, whereas history is everywhere. The next chapter deals with transformers, and describes the open and closed circuit and the continuous-current transformer. It is a pity that the illustration of the latter is so bad, for as a rule the illustrations are excellent. The various systems of distribution next claim attention, and here again the descriptions are simple and the illustrations excellent. Unfortunately, the author never seems to think of any other end than answering examination questions, and thus he deals too much with descriptions rather than with principles. Little real knowledge of the subject and no originality is required for such mere descriptive matter, and our author can do better if he likes; but these questions at the end of each chapter have hampered him. Still, the questions as given are of great use, only if the information enabled constructive questions rather than descriptive, they would be better. After a chapter on fuses, regulators, earthing devices, and similar things, we come to a chapter which will prove one of the most valuable to the student. This is a chapter of worked examples, and admits of what we term constructive questions. The value of such a chapter we will attempt to explain. When a student gets mere description, and has to take his place in actual work, he is unable to design under circumstances which differ considerably from those named in his books. Hence, a book intended for students should tackle principles as well as description in order that the reader may be able to apply those principles in practice. You cannot too often explain principles, nor should repetition be avoided if it will assist to drive home the principle under discussion. Hence, we are inclined to think that this one chapter will do more to aid the student than the remainder of this part. Of course, our remarks are somewhat out of place, in that the whole work has a special object, that of preparing for a certain examination, and thus the author is bound to consider the requirements of a syllabus. No matter how such a syllabus be drawn, it must hamper an author, and while he may produce an admirable book for the purpose intended, it might without such restriction be useful for a wider *clientèle*. Students of the City Guilds' examinations will no doubt make this their text-book, and will find it giving what they require; but we wish examinations of the cut-and-dried kind now fashionable were abolished, and leave teacher and author with greater freedom.

INSTITUTION OF ELECTRICAL ENGINEERS.

The first meeting of the autumn session of this Institution took place on the 9th inst., Mr. W. H. Preece, F.R.S., president, in the chair.

The **Secretary** (Mr. Webb) read the minutes of the previous meeting, which were confirmed, and the names of candidates for election and transfer. The following names were then mentioned of donors to the library:

Foreign Member.—Mr. Nikola Tesla.

Members.—Messrs. C. H. W. Biggs, A. Fahie, and Druitt Halpin, Profs. A. Jamieson and A. B. W. Kennedy, Mr. W. Perren Maycock, Prof. H. Robinson, Sir David Salomons, Messrs. J. N. Shoolbred, A. Siemens, and A. Campbell Swinton, and Sir Charles Todd.

Associates.—Messrs. C. E. Hawkins, L. Newitt, J. T. Niblett, J. Munro, and R. W. Weekes.

Non Members.—The Astronomer Royal, Mr. F. B. Behr, the Director General of Telegraphs (India), Messrs. C. Griffin and Co., M. E. Jacquay, Minister of Posts and Telegraphs (Rome), the Radcliffe Library (Oxford), and Mr. T. C. Webb.

Prof. George Forbes, F.R.S., then read the following paper on

THE ELECTRICAL TRANSMISSION OF POWER FROM NIAGARA FALLS.

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Introductory.

I had originally intended the title of this paper to be "The Transmission of Power by Electricity," but I found on writing it that it was inevitable that the work on which I am engaged as electrical consulting engineer at Niagara Falls should take a very prominent part in its substance, but the paper does still deal with the general question. On the 14th of December, 1892, I read before the Society of Arts a paper on "The Utilisation of Niagara Falls," in which the general plan of operations was described. But at that time the electrical developments were not sufficiently advanced to enable me to treat of that part of the subject. A reference to that paper will prevent the necessity of my wasting time in describing in detail the civil engineering and hydraulic arrangements. The object of the present paper is to put before this Institution the circumstances under which this great problem has been attacked, and the views which have been arrived at, and also to describe, so far as any work has been done, the electrical machinery to be installed.

The utilisation of the Falls of Niagara has long been a favourite theme of engineers, but it was not until the transfer of power by electricity became feasible, that this could enter very satisfactorily into the region of practical engineering. The matter is now in the hands of one of the most powerful combinations of New York capitalists which has ever been formed. Under their auspices the matter was, for the first time, thoroughly investigated from an engineering, financial, and commercial point of view. Rights were then acquired, and companies formed. The Cataract Construction Company does the engineering work, and will then hand it over to the Niagara Falls Power Company. The Land Development Company builds a whole village on the extensive lands acquired. The Niagara Junction Railway Company constructs six miles of terminal railway to connect all the factories, as they are built, with the railways in the neighbourhood. Rights of way are obtained in many directions, and also over the Erie Canal, which connects the Niagara and Hudson rivers. Allied companies are formed to develop power to all the cities within reach. Roads are made, leases of land granted, factories built, and the engineering works taken in hand by the Cataract Construction Company. It is with this latter that we have chiefly to deal. Mr. E. D. Adams is the president, Mr. F. L. Stetson the first vice-president, and Mr. E. A. Wickes second

vice-president, Mr. W. B. Rankine is secretary and treasurer, Mr. G. B. Burbank is the chief engineer, and Dr. Coleman Sellers acts both as consulting engineer to the Cataract Construction Company and president of the Niagara Falls Power Company, while undertaking at the same time many of the duties of resident engineer. The waters from the river are taken in at a point about a mile and a half above the Falls by a canal, from which it is led, by channels, into a long slot in the ground, going to a depth of 200ft. In this slot are iron pipes, or flumes, down which the water is carried to the turbines, and the waste water is carried through a tunnel for a distance of 7,000ft. to a point a few hundred yards below the American Falls, where it discharges into the lower river. Each turbine is of 5,000 h.p., revolves at a speed of 250 revolutions per minute, and is mounted on a vertical shaft. Above it there is a shaft extending in a vertical direction to the surface of the ground, on which a power house is built and the revolving part of the dynamo is placed directly upon the top of this shaft. The present paper may be divided into two distinct parts - first, the plans of working, of which, as their consulting electrical engineer, I have recommended the adoption; and, second, the design of the machinery which is to be used. In neither of these two parts can I claim to have done anything of great novelty or originality. I have simply collected together the results of experience which are available to all engineers, and in any advice that I have given I have simply followed the logical conclusions that were to be derived from the past experience; and in this I have been benefited by the courtesy and kind assistance of professional men, inventors, and manufacturers in both continents, who, almost without exception, have put their experiences at my disposal. If I have been the instrument to put before the company any designs of value, it has been to a great extent as the assembler of ideas which have originated as often in the minds of the engineers and draughtsmen who have given me their assistance, as in my own. I wish especially to express how much the company is indebted to Prof. Coleman Sellers, one of the most distinguished mechanical engineers in the United States, and who has assisted me throughout with his advice and suggestions, and who may be said to have originated the form of bearings and their supports which are to be used in the Niagara dynamos. I have also received valuable suggestions from my colleagues, Prof. Unwin and Colonel Turrettini, and also from the draughtsmen who have assisted me, and from numerous friends in our profession.* I have been desired by the president of the company to take this opportunity of stating some of the events which have culminated in the present satisfactory position of the company with regard to its contracts for machinery.

Relative Advantages of Direct and Alternating Currents.

A few years ago it would have been considered necessary to devote a considerable amount of space to the discussion of the relative merits of direct and alternating currents. During the last two years, however, opinions have advanced so steadily in the direction of preferring the alternating current for the transfer of power to any considerable distance, that it is not necessary to give much time to this question. One of the chief difficulties in connection with using the direct current is that it is necessary, for getting the best results, to connect a number of dynamos in series, and also to put the motors at the receiving end in series with each other. This involves the insulation of each dynamo and motor from the earth – a requirement which can in some cases be attained, but which in a general system of distribution is apt to be attended with difficulty, and perhaps with danger. The best case of the kind which has been put in practice is that of Genoa, and we gave it the most serious attention, but came to the conclusion that, for our purpose, it was undesirable. The facility which the stationary transformers used with the alternating current give for varying the pressure according to the requirements of economy or safety, is one great feature in favour of the alternating current. The question was considered in all its bearings with the utmost care, and it was not until the month of May, 1893, that the board of directors passed the resolution to adopt the alternating current, both for their distant transmission and also for the works nearer to the power house. It was proposed, indeed, by some manufacturers to distribute the current within a radius of a mile or two at 700 or 800 volts, and one firm proposed to do this by means of a direct current. Had this plan been accepted, we should have arrived at the surprising result that by using the continuous current at 700 volts within a mile or two, and high-pressure alternating current for more distant places, it would have cost more to produce a horse power per annum at Niagara Falls than at Buffalo.

The argument that seemed to me the most important in favour of using the direct current was, that motors for this purpose have been made in much larger quantities than alternators, and that it would be seldom necessary to build special types of machines to act as motor. This advantage seemed to be of great importance, until I realised the value of a low frequency used with the alternating current. So soon as we reduce the frequency low enough, we are able to alter a direct-current motor into a synchronising alternating motor, by the simple addition of a couple of rings placed on the commutator and electrically connected with opposite bars of the commutator, and a brush rubbing on each of these collecting rings. I also took into consideration the question of the possibility of storing up energy in storage batteries during the night time, when, of course, the demands on our plant would be least, and giving it off during the daytime; but at the present time the cost of the batteries would not repay work in this direction, and it would be cheaper to make another tunnel, with wheel pits, turbines, and all the paraphernalia required to generate current, than to go to the expense of putting down the large amount of lead which is required for these batteries. With the alternating current we have the choice of a considerable number of motors of different types. We have the synchronising motor, the series wound motor with laminated field and commutator, the multiphase motors, which attracted so much attention at the Frankfort Exhibition of 1891, and a host of single phase motors which have been developed by various inventors, but which have never been placed on the market because of the high frequency which has been prevalent, and with which they were not altogether satisfied. These motors become immediately available if we use a lower frequency. The generation of an alternating current also permits of the use of a commutator, or rectifier, with direct current motors.

Number of Phases.

Assuming now that it is generally agreed that the alternating current must be adopted not only for the distant transmission, but also for the nearer work, the next point to consider is the number of phases - whether the current should be generated in a single phase, in two phases, or in three phases. The possibility, too, of using even a greater number of phases was also considered, but it did not seem to possess advantages.

As already stated, there are many motors which are suitable for use with a single phase at low frequency, and which start without assistance. In the workshops of nearly all the most able electricians which I have visited in the course of the last year or two, I have found such motors built upon different plans, and nearly all of them seemed to work fairly well, and promise to be very efficient at low frequency.

For all heavy work which is going on constantly without stopping the machinery, no motor could be more suitable than the synchronising alternator on a single phase, and its speed is as regular as that of the turbine which is developing the power. It seems, however, that even if single-phase motors are going to be adopted, it would be best for the generator to have two phases, because in this way we get a larger output for the same size and price of machine, the circuits may be perfectly independent, and supply separate motors. Also the two-phase system makes the rectification or commutation of the current more easy to use it for street railways, electro-metallurgy, etc. Again, multiphase motors have a great advantage that they have been considerably utilised already, and even in small sizes have a fairly good efficiency.

With regard to the relative merits of two and three phases, several claims that cannot be supported have been put forward in favour of the latter. First, it is claimed that the saving in the copper on the line is 25 per cent. over a one-phase system, and 25 or 13 per cent. over a two-phase system, according as four or three wires are used for the purpose. I investigated this matter carefully, and arrived at the conclusion that this was not the case, and that the three-phase system had no advantage in this respect over a two-phase system with three wires. Second, it is claimed that there is a greater simplicity of wiring with three phases than with two phases; but this advantage disappears when we remember that the two-phase system can be used with only three wires, although this is not a plan which I would recommend. Third, it is claimed that any pair of the three wires may be used for a distribution of lighting. This is not the case. A two-phase system, where the circuits are completely independent, is much more suitable for the purpose, and maintains the lights at a more constant electric pressure. Fourth, it is claimed that there is a smoother starting and rotating effort with the three-phase than with the two-phase system. This was originally claimed on theoretical reasons only by Dobrowolski, but everyone who has used the type of two or three-phase motors made by the Oerlikon Company, by C. E. L. Brown, and by the Allgemeine Elektricitats Gesellschaft, of Berlin, and others, is convinced that this advantage, which seems probable enough, is purely theoretical; it is not confirmed by actual practice, and, moreover, when the fact is known, the theoretical reason is pretty evident.

No other claims in favour of the three-phase system over the two-phase have ever to my knowledge, been advanced; and, as shown above, a very full consideration of these claims does not tell in favour of the three-phase.

I will now point out what seemed to me great objections against the three phases, due to the fact that the three conductors are all inter-connected. First, it introduces trouble in maintaining the efficient working of the line, and in testing it, so that a higher type of electrician would be required to make these tests, and even he would have greater difficulty in finding the faults and correcting them. Secondly, when the three circuits are unequally loaded the electric pressure varies considerably. These difficulties have been thoroughly appreciated by workers in this line. When an inter-connected set of circuits such as the three-phase system employs is used, it is found that when the circuits are unequally loaded there are great variations in the electric pressure, and the following tests were made at my request to illustrate this. The three circuits are called A, B, and C. The average electric pressure of the three branches at the terminals of the secondaries was maintained constant. A resistance tending to reduce the electric pressure at the lamps 5·3 per cent. was introduced into each branch. Both the primaries and the secondaries were connected as represented by the form of the letter Y. By varying

* I must mention the names of the following draughtsmen who have worked on the dynamo designs for me. In England, Mr. F. M. Weymouth was chief draughtsman, assisted by Messrs. A. Wilson, R. H. Simpson, G. E. Groom, F. Wilby, W. L. Hamilton, W. M. Williams, and W. H. Hudson. In America, Mr. Baumann was chief draughtsman, assisted by Messrs. Steen and Jacobsen; Mr. Vogel also worked for me there.

the connections in different ways, some slight variations were possible; but this general fact remained, that when A is loaded and B and C are not loaded, the pressure of A is less than that of C, and that of C is less than that of B, and the difference may be 12 or 13 per cent.; and when A and B are loaded and C is not loaded, the pressure of A is less than that of B, and that of B is less than that of C. The variations here shown in the pressure of two equally loaded circuits is probably due to the armature reactions, and would be found in a two phase system also; but the rest of the variation is due to the inter connection of the three circuits, and is an obvious defect of the three phase system. In order to get over this difficulty, the Oerlikon Company proposed to devote only one circuit to lighting purposes, which shall be maintained at constant pressure, using the other two circuits for power purposes, where constancy of pressure is not so important. In some cases this would be a suitable method of working, but it was not considered satisfactory for the work at Niagara Falls. Having considered these points, the board of directors of the Cataract Construction Company at their meeting in May, 1893, determined to reject the three phase system, leaving the single-phase and the two-phase available.

Conditions.	Volts at terminals of lamp mains.				Difference between maximum and minimum volts.
	A.	B.	C.	Average.	
A, B, and C loaded (resistance out)	108·5	108·6	107·9	108·3	0·7
A, B, and C loaded (resistance in)	103·5	103·6	103·2	103·4	0·4
A loaded, B and C off	102·9	116·0	106·5	108·5	13·1
B loaded, A and C off	104·5	102·5	114·9	107·3	12·4
C loaded, A and B off	115·1	105·3	101·3	107·2	13·8
A, B, and C loaded (resistance in)	103·0	103·4	102·5	103·9	0·9
A and B loaded, C off	98·9	107·8	111·1	105·9	12·2
A and C loaded, B off	101·2	108·0	98·1	102·4	9·9
B and C loaded, A off	110·5	98·0	105·8	104·8	12·5
A, B, and C loaded (resistance in)	103·7	103·0	103·0	103·5	0·7

Frequency of Alternations

I wish now to say some words on a question which has absorbed my most serious attention, especially since I have been acting for the Cataract Construction Company, and this relates to the frequency of the alternating current. In America a frequency has generally been adopted of 133 complete periods per second for lighting purposes. This was done with the object of reducing the cost of transformers, which were supplied to each separate house, and consequently were always of small size, and therefore expensive. The selection was also approved because American engineers working with alternating currents have generally put forward the view that parallel work is not desirable, and the fact that parallel working is more difficult at high frequency, which is one of the principal objections to high frequency, has not been seriously considered in America. In Europe the usual frequencies are from 70 to 100 periods per second, but a notable exception exists in the case of Messrs. Ganz and Co., of Budapest, who have adopted 42 periods per second. Some years ago I unwittingly did Messrs. Ganz the injustice to say that I thought it probable that they had adopted this frequency because it suited their particular type of machinery and speed of running. I have it in writing from them, and I am thoroughly convinced of the truth of it, that their reason in adopting the frequency of 42 periods per second was that it is the lowest frequency that is available with arc lights so as not to produce any serious flickering, and their desire was to lower the frequency as far as practicable in order to ensure parallel working. Of course, it is a matter of common knowledge that parallel working is assisted by lowering the frequency.

With the large units which will be employed in connection with the Niagara Falls scheme, the cost of the transformers is very much diminished; and this does not become so important a matter as it does when all the transformers are of small size — under 10 h.p., as is usual in electric lighting in America. Moreover, although with lower frequency the transformers must be increased in size, the increased cost is not in proportion to the lowering in frequency, because we can use a higher induction. Mr. Steinmetz has shown that the loss due to hysteresis varies as the induction raised to the power 1·6, and it is this loss which must be kept constant when we vary the frequency. I deduce from this law the fact that in any transformer, if the hysteresis loss is kept constant, its power of doing work varies in proportion to the frequency raised to the power 0·4 (but it is probably unwise to increase the induction so much as to saturate the iron). It follows that when we double the frequency we get out of the same transformer 132 units of work instead of 100. If the frequency were quadrupled, we should get 174 units instead of 100. I have been informed by Mr. William Stanley, jun., of Pittsfield, Mass., that without the use of theory, but simply working from his experience in manufacturing and testing transformers, he obtains almost identically the same law; and I have got independent practical testimony in the same direction from other manufacturers. It appears, then, that there can be no doubt that in lowering the *frequency we are not proportionately increasing the cost; but at the same time it must be realised* that the cost of transformers is to a certain extent increased by lowering the frequency. If the frequency be reduced to one half, the cost is increased about 50 per cent. The lowest price which has been quoted for large transformers is 3·52dol. per horse power, at a frequency of 42 periods per second. In halving the frequency the extra cost would therefore only be 1·76dol. per horse-power. It becomes, then, a matter of enquiry whether the benefits to be derived by lowering the frequency in such a proportion would compensate for the extra expenditure as indicated. I am thoroughly convinced that the gain is far in excess of this amount. I shall have occasion to discuss the superior efficiency of motors at low frequency; and in most types of motors I think it safe to say that in passing from 42 periods to 21 periods, or varying the frequency in that proportion, we have a gain of at least 3 per cent. in the efficiency of the motors. Neglecting altogether the increased value of the motors from this cause, there is 3 per cent. more power at our disposal, which, at only 10dol. per horse power per annum, would amount to 30 cents per annum, or, capitalised at 5 per cent., represents an increased value of 6dol. per horse-power of the plant, against which we have the increased cost of transformers — only 1·76dol. It appears, then, pretty certain that, from a purely economical consideration of the question, a lower frequency than any which has hitherto been adopted is advantageous.

With regard to the lowest limits at which we can work, since our turbines have been designed to revolve at 250 revolutions per minute, a two poled dynamo — if such could be satisfactorily constructed — would give a frequency of 4⅙ periods per second, and none of the synchronising or polyphase motors employed at different factories could run at a higher speed than 250 revolutions. I am not sure that it is desirable that any motors should run at a higher speed than this, but in the few cases where this might be desirable the use of belts would be quite natural in order to give the higher speed. With a four-poled machine we would have a choice of speeds at 500 revolutions, 250 revolutions, and any sub-multiple of these speeds; for by increasing the number of poles in the motor the speed of the motor can be reduced as much as we please. With eight poles in the generator, the maximum speed is 1,000 revolutions per minute, which is as high a speed as would generally be desired in connection with the factories supplied from Niagara Falls. This frequency is 16⅔ periods per second, and after considering the three points — namely cost of transformers, speed of synchronising motors, and convenience in the design of the generators — I came to the conclusion that, so far as motive power was concerned, this is the frequency which would be most favourable for use at Niagara Falls.

Another indirect advantage of using a low frequency is of a very practical nature, and lies in the fact that the ordinary continuous current dynamos of any size that are made may be used as synchronising motors by means of rings attached to the commutator bars in the manner which has been above described. This method of altering and working a direct-current motor so as to make it suitable for an alternating current of low frequency has long been known to electricians, but the attention of those who are not experts was forcibly directed to it by the machines shown by Mr. Schuckert and others at the Frankfort Exhibition in 1891. Owing to this fact, it would be possible for any manufacturer connected with our supply station to procure a motor of low frequency of any moderate power he might require at a day's notice, and this is not true of any other alternating motor, nor is it true of a higher frequency.

But the most obvious advantage of low frequency is the improved efficiency of motors. I have arrived at this conclusion from my own observations, but I find it confirmed collaterally. With synchronising motors, of course, the fact has long been thoroughly established that the performance is very much improved by using low frequencies. Again, those who have used the motors with rotating field of the two phase or three phase type have all been obliged to reduce the frequency of the current to get the best results. In this connection I am pleased to be able to show a diagram giving some tests which were made for me of a three-phase motor at 41 complete periods per second, and at 56 periods per second.

It will be noticed that at 56 periods the maximum efficiency is given when the output is 17 h.p. It is then 85 per cent., and the efficiency at 41 periods per second at the same output is 87 per cent. But it will be noticed that the efficiency at the latter frequency goes on increasing until the output of the machine is 19½ h.p., when the efficiency rises to nearly 88 per cent. Thus, by lowering the frequency from 56 to 41 periods per second, not only had the output of the motor been increased 15 per cent., but the efficiency had also been increased 3 per cent. It is also found — which is a matter of the utmost importance — that in every self starting alternating motor, whether multiphase or otherwise, the effort at starting is increased by lowering the frequency.

Again, I find that the ordinary direct-current motor with a laminated field works extremely well with low frequency; even without lamination of the field it works, though not well. I have consulted nearly every electrician of experience in this direction whom I have met during the last year or two, either in Europe or America, on this point, and they generally agree with me that the facilities of working motors of whatever kind are very much greater with a low frequency. Last year, being aware that Prof. Anthony had experimented considerably in the direction of series wound motors with laminated field, I asked him his opinion, and he expressed himself as follows:

"In reply to yours of August 30, I have built two or three continuous current machines with laminated fields to run with alter-

nating currents, and have succeeded in running motors of about ½ h.p. directly from the Westinghouse converter, where the frequency is some 130 per second. Such small machines run very nicely where the alternations do not exceed 25 per second. In fact, so far as I have tested, they seem to give an output fully equal to what they will with continuous currents. Of course, with high frequencies the self-induction of the field is against their working, but at eight per second I should say that large motors could be run with perfect success."

I wish to repeat that, from what I have seen in the workshops of all advanced electricians in the last year or two, I am confident that in the near future single-phase alternating current motors, self-starting on full load, will be largely used; and there is not the slightest doubt that all of these work far better with low frequencies. In fact, as Mr. Brush once said to me when I was discussing this matter with him, "Really, your best plan would be to lower the frequency so much that you get a direct current."

Whilst speaking of low frequency in relation to motors, I must say that I have much greater hopes of obtaining a good commutating device with a low frequency than with a high one; and I will also state that I have great hopes of important advantages coming to us from the invention of such a commutating appliance which will enable us to furnish street-railway companies, electro-metallurgical works, and other consumers with the direct current without the use of any heavy revolving machinery at the transforming station.

I am not sure that it ought not to be said that the greatest advantage of low frequency is in connection with the conductors used for transmission, and in the parts of the apparatus that require high insulation. When a high frequency is used there are certain difficulties which are well known. The first of these has been strongly urged by Lord Kelvin—namely, that when using large conductors an alternating current of high frequency tends to confine itself to the outside of the conductor, thus increasing the total resistance. Attention was first generally directed to this subject by the presidential address of Prof. Hughes to this Institution. A second difficulty is that with high frequency the impedance of the line due to the magnetic field formed between the go and return wires may amount to a very sensible quantity. Attention has been drawn to these matters by Mr. A. E. Kennelly, and his paper* on the subject should be carefully studied. Then, again, with high frequency there is a greater tendency to discharge from an electrified conductor into the air. This means that the insulating of a bare conductor is more difficult with a high than with a low frequency. Lodge and others have made this very manifest with exceptionally high frequencies, but the truth of the statement is well known by those who have experimented even with low frequencies. Another trouble is that, whenever it is necessary to use solid insulation, a current of high frequency has a greater tendency to injure the insulation. Mr. Tesla has shown and explained so clearly the rapid deterioration of solid insulation by currents of enormously high frequency, that we cannot fail to see that advantage is gained by using currents of low frequency. Another very important fact is that with low frequency we are less troubled by the capacity of cables, and we have less loss of static charge accompanied by heating of the insulation. Again, the serious troubles which have been encountered at Deptford and elsewhere owing to abnormal rises of electric pressure in the mains above the pressure generated by the dynamos, due to the resonant effect produced by the capacity of the cable and the self-induction of the circuit, may be reduced as much as we please by sufficiently lowering the frequency. All these facts are the explanation of what has been thoroughly established in actual practice—namely, that there are difficulties on the line when using high frequencies which tend to loss of power and to destruction of the insulation, and that these difficulties are largely mitigated, if not entirely obviated, by reduction of the frequency. It must also be remembered that if we reach a frequency as low as 16 periods per second, any induction in neighbouring telephone circuits is utterly inappreciable by the ear. Finally, all eddy currents diminish as the square of the frequency. Having now stated as clearly as I can what seemed to me the principal advantages of low frequency, I will place on the other side the disadvantages.

Besides the increased cost of transformers, there is one fact which is apt at first sight to impress one as almost fatal to the employment of very low frequency, but which further consideration shows to be of little moment in the case of Niagara Falls—this is, that a low frequency is not suitable for electric lighting directly. But it must be remembered that it is decidedly preferable to use a direct current for arc lamps, and, in fact, in the present position of the art in America it would be almost a necessity. Hence the natural method of arc lighting would be to use the alternating current by means of a motor to drive the well-known arc lighting machines. In the course of the work at Niagara, the first work in connection with arc lighting which will be set up is the lighting of Buffalo. At present this is done by means of steam engines, developing about 3,000 h.p., and driving arc lighting machines of the Brush, Thomson-Houston, and Wood types. There cannot be a doubt that, financially and practically, the best way of converting this station to enable them to use the power from Niagara Falls is to put in alternating motors in the place of the steam engines, and this will be the case in most of the towns which will be supplied with power from Niagara Falls.

(To be continued.)

* "Impedance," by A. E. Kennelly, American Institute of Electrical Engineers, April 18th, 1893.

PHYSICAL SOCIETY, Nov. 10, 1893.

Prof. A. W. Rucker, M.A., F.R.S., president, in the chair.

Mr. R. S. Cole was elected a member of the society.

A paper "**On the Separation of Three Liquids by Fractional Distillation**," by **Prof. F. R. Barrell, M.A., B.Sc.; G. L. Thomas, B.Sc.; and Prof. Sydney Young, D.Sc., F.R.S.** was read by Prof. Young. Accepting the results obtained by F. D. Brown in his experiments on the variation in the composition of the distillate from a mixture of two liquids—viz., that the relative quantities of the two substances in the vapour at any instant are proportional to the weights of the substances in the still multiplied by the ratio of their vapour pressures—the authors write Brown's equation in the form $\frac{d\xi}{d\eta} = c\frac{\xi}{\eta}$, where ξ and η are the weights of the two liquids in the still, and c the ratio of their vapour pressures. Taking c as constant, the above equation is integrated, and from the resulting expressions curves are plotted showing the changes in composition that take place during the distillation. Assuming that a similar law holds for three liquids, A, B, and C—viz., $\frac{1}{a}\frac{d\xi}{\xi} = \frac{1}{b}\frac{d\eta}{\eta} = \frac{1}{c}\frac{d\zeta}{\zeta}$, the composition of the distillate at any instant is calculated. Taking $a = 4$, $b = 2$, and $c = 1$ (numbers nearly proportional to the vapour pressures of methyl, ethyl, and propyl acetates), numerous curves are plotted, showing the progress of the separation at various stages of fractionation. These curves show distinctly that although fractions containing large proportions of the liquids A and C, of lowest and highest boiling points respectively, can be easily separated, the middle substance, B, is much more difficult to obtain in a state of purity. Consideration of these curves led the authors to see that by carrying out the fractionations in a particular way, it was possible to separate the mixture into two portions—one containing only A and B, and the other B and C. These mixtures of two liquids could then be fractionated in the usual manner. This process was carried out on a mixture of methyl, ethyl, and propyl acetates the results of which are given in considerable detail in the paper. The remarkable agreement between the densities of the ethyl acetates obtained respectively from the mixtures (A and B) and (B and C), as well as the fact that the densities of the separated liquids were the same as before the mixing, show conclusively that the method employed was highly successful. **Prof. Ramsay** said the paper was a most valuable one, and would be a great aid to chemists. Distillations were usually carried out by mere "rule of thumb," with the result that absolutely pure liquids could rarely be obtained. The **President** enquired whether curves representing the progress of distillation could be constructed from the very complete experiments made, and so test the assumed law. **Prof. Young** thought this not possible from the numbers obtained. To test the law in this way would be very laborious.

A "**Note on the Generalisations of Van der Waals's Regarding 'Corresponding' Temperatures, Pressures, and Volumes,**" was read by **Prof. S. Young.** In November, 1891, the author read a paper on the same subject (*Philosophical Magazine*, February, 1892), and gave the critical molecular volumes of some 12 substances as calculated by M. Mathias. Since then, a few small errors have been found in the calculation, and the author's corrected values are now given. The vapour pressures, molecular volumes, and critical constants of 10 esters (methyl formate, acetate, propionate, butyrate, and isobutyrate; ethyl formate, acetate, and propionate; and propyl formate and acetate) have recently been determined (*Transactions* Chemical Society, vol. lxiii., page 1,191). In the present paper the absolute temperature and volumes of the 12 substances are given in terms of their critical constants, and tables given showing respectively the ratio of boiling points (abs. temps.) at corresponding pressures to absolute critical temperatures, the ratios of volumes of liquid at corresponding pressures to the critical volumes, and ratios of volumes of saturated vapour at corresponding pressures to critical volumes, for the halogen derivatives of benzene, benzene, carbon tetrachloride, stannic chloride, ether; methyl, ethyl and propyl alcohols, and acetic acid; and the extreme values for the 10 esters previously mentioned. Whilst showing fair agreement with each other, the differences between them exceed errors of experiment. The ratios also indicate that the substances can be arranged in four groups, thus tending to show that molecular weight and chemical constitution have some influence on the results. The differences found would probably result from the presence of complex molecules such as are known to exist in acetic acid. If Van der Waals's generalisations were strictly true, the ratios $\frac{PV}{T}$ at the critical point should be constant for all substances, as also the ratio, $\frac{D}{D'}$, of the actual to the theoretical density (for a perfect gas) at the critical point. On comparing these quantities, only a rough approximation is found, but the grouping of the compounds is again well marked. **Prof. Ramsay** was not sure that the existence of complexes would alter the molecular volume in the liquid state, for liquids seem very compact. Experiments on the surface energy of liquids had proved that complex molecules do exist in the alcohols and acetic acid. Dr. Young's conclusions were therefore confirmed by experiments of an entirely different nature. **Prof. Herschel** was gratified to see Van der Waals's theory so well borne out in liquids, and hoped to see it extended to solids. The recent researches of Prof. Roberts-Austen on alloys seemed to point in this direction. **Mr. Rogers** said molecular complexes, &c.

exert an influence on the properties of substance as had been shown by Prof. Thorpe's viscosity experiments Van der Waals's generalisations should, therefore, be looked at from a chemical as well as a physical point of view. The **President** thought the numbers brought forward showed fair agreement, especially when it was remembered that Van der Waals took no account of complex molecules Contrary to Prof Ramsay, he would rather expect aggregation to affect the molecular volumes in the liquid state, for only about one-fifth the space was supposed to be occupied by matter On the other hand, the relatively small contraction of liquids on cooling did not support this view

"**An Instrument for Drawing Conic Sections**" was exhibited and described by **Mr J. Gillott, B.A.** This consists of a spindle inclined to a plane board, and a tube fixed to the spindle at an angle A pencil, which passes through the tube, traces out a cone in space as the spindle is turned, and on sliding the pencil through the tube so as to keep its point against the plane, the point traces out a conic, the section of the cone made by the plane of the board. A circle, ellipse parabola, or hyperbola can be drawn according to the inclination of the spindle to the board **Prof Henrici** said a similar instrument had been described in an Arabian manuscript 1,000 years old, and had been independently reinvented by both a German and an Italian mathematician. He thought the fact of the angle between the spindle and the tube in Mr Gillott's instrument not being adjustable, was a disadvantage **Mr Inwards** and **Prof Herschel** also took part in the discussion, to which **Mr Gillott** replied

ELECTRIC LIGHTING AT KENSINGTON.

We have before referred to the report of Major General Webber and Mr Philip Monson to the Electric Light Committee of the Kensington Vestry, but we think that a portion, at any rate, of this report is of considerable interest to many local authorities who have to deal with the getting rid of house refuse as well as lighting questions. At the present time Kensington has to pay a large sum to get rid of certain refuse, hence in a report of this kind the question was certain to arise whether the destruction of refuse and the production of light could not be carried on at the same time The report states that in the district there are probably by this time nearly one hundred thousand 8 c.p. lamps connected with the four generating stations The companies in the district have capital invested to over three hundred thousand pounds. The report considers, first, the advisability and practicability from an economic point of view of consuming the refuse of the parish to produce electrical energy. To obtain information upon this point the destructor furnaces at Kidacre-street, Leeds, were visited, which furnaces deal with about 25,000 tons of refuse per annum, working three shifts a day, each of eight hours The authors have adopted "the reports of the use of refuse at Birmingham for producing steam namely, that in practice 1lb of refuse will evaporate 1·79lb of water the 25,000 tons of refuse at Leeds should be able to evaporate 44,750 tons of water, working six days a week, which at 25lb per indicated horse power, gives in 7,488 hours 530 h.p at one time thus quite confirming the superintendent's statements as to the practical calorific value of the Leeds refuse This result is obtained under unfavourable conditions, as the flues, owing to the previous existence of the chimney stack, are not designed as favourably for the utilisation of the draught, etc, as they might otherwise have been, and as the refuse consumed contains quite one-sixteenth more market refuse than the average from houses such as those in Kensington"

The second point considered was as to the advisability and practicability from an economical point of view of utilising any, and if so, which of the Vestry's wharves or depots for the erection of generating stations or other works.

The following estimate is given on this point: Our estimate of the outlay required for the destructors, with the land and buildings, but exclusive of the electrical generating equipment and boilers, is as follows:

Destructor house, with 12 destructors complete, with forced draught, flues, by-pass, etc., including cost of cofferdam to exclude canal water, etc.	£6,000	
Shop	230	
Chimney shaft	750	
Freehold value of site	1,700	
		£8 610
Boiler roof and flues	700	
Electric light station buildings	2,100	
		2,800
		£11,480

If electric light is excluded entirely and the site is occupied by what is required for destruction of refuse only, this figure will be reduced to £8,680

If it is used for an ordinary electric light station without any means of destruction of refuse, this figure would be reduced to £5 380

If either of the two alternatives was adopted the site would afford space for an extension of plant; but if the two processes are combined, the whole site is fully taken up at once, as described in paragraph 16.

Thirdly, "As to the advantages which it is suggested or can be shown would accrue to the consumers and ratepayers generally by Vestry undertaking the supply of electricity for public and private *purposes throughout* the whole or any part of the parish"

As already stated, we believe we are right in regarding the question of the Vestry becoming undertakers for the supply of electricity in competition with the existing supply companies within the areas allotted to them as one which is not at present ripe for consideration, as it opens up questions of demand, supply, and profitable expenditure of capital of a very complicated nature.

It seems desirable at this stage of our report to remind the Vestry that in the last five years the distribution of electrical energy both for light and power, in towns all over the world, has reached a position of practical application as an industry, not only as a public necessity, but also as a remunerative investment not far behind that which has been attained by its elder sisters namely, the supplying of gas and water In other words, that it is well advanced into its period of adolescence, and that all the conditions which are required to make it pay are thoroughly understood.

The anticipations during the early history of electric lighting in this country as to its general adoption have been disappointed because of their exaggeration: but estimates made 10 years ago of the probable demand in residential districts of London, based on one private house in three using the light within five years of starting to supply current, have been more than fulfilled There are reasons why such an estimate based on one house in four as regards the district with which it is proposed to deal should not be again excessive, in spite of the fact that in the latter the average ratable value of the property is much below that of other parts of Kensington

They are as follows: (a) It is found that the wiring of existing houses for the electric light is not often done except when the occupation changes. The owner has less inducement to wire his houses when once they are let, and the tenant, for a term, will rarely incur the outlay on a house not his own. Shorter tenure of occupation entailing more frequent changes of occupiers, which is the case in the less wealthy districts, should therefore give more frequently need and opportunity to carry out wiring (b) Wiring and fittings are costing 50 per cent. less than they did five years ago. This applies especially to fittings. For instance, a good 20-light distribution board can be now procured for about 18s. instead of former prices varying between £2 and £5. (c) Excellent energy meters satisfactory to the Board of Trade will soon be sold for less than 30s (d) Incandescent lamps will shortly be sold for 1s 3d. now, and be repairable for 6d. each, and there can be no doubt that a greater efficiency of the filament will ere long be provided, so that the same light will be yielded with a less consumption of current than now. If, in addition, the Vestry can, without incurring a loss sell current for 5½d. a Board of Trade unit, which is equivalent to 16 candle gas at 3s. 1d. per 1 000 cubic feet in the ordinary burners, the conditions for bringing this illuminant within the reach of all who now use gas are obtained, and the consumers will reap besides all the advantages to health and comfort, economy and safety recognised as accompanying the use of electricity.

As against the above inducements to an extension of the use of electric light into such districts based on the usual condition, which naturally influences an electric light supply company—namely, that it is an illuminant only accessible to the wealthy—we have compiled the following tables, which divide the custom between private houses and shops, and which also subdivide the same in groups according to rating, so that the proportion of each kind in each electric light district may be seen at a glance These figures show clearly the preponderance of the number of houses and shops at the lower ratings in Districts 1 and 2 as compared with the others.

TABLE showing the Decimal Proportion to the Whole Number in Groups according to Rating in each District.

Private Houses.

Districts.	£50.	£100.	£150.	£240.	Over £250.
1 and 2	·565	·331	·129	·032	·010
3	·101	·201	·283	·206	·165
4 and 5	·039	·110	·170	·337	·466
6	·295	·358	·418	·425	·359
	1·000	1·000	1·000	1·000	1·000

Shops.

Districts.	£50.	£100.	£150.	£240.	Over £250.
1 and 2	·621	·381	·178	·078	·087
3	·176	·258	·219	·174	·110
4 and 5	·056	·149	·294	·428	·593
6	·147	·219	·309	·320	·210
	1·000	1·000	1·000	1·000	1·000

The areas under consideration are shown by the map which is attached to this report, and include about three-elevenths of the parish, and lie to the north of Uxbridge-road, Ladbroke-grove, and Archer-street. Their length together is approximately 1½ miles from north to south, and 8½ furlongs from east and west. The following streets and portions of streets that we have selected and propose should be dealt with first are coloured on the map, and are selected as those in which a demand under the conditions we have mentioned may be fairly expected: Bassett-road, Blenheim-crescent, Cambridge-gardens, Colville-square, Colville-terrace, Clarendon-road, Elgin-crescent, Ladbroke-gardens, Ladbroke-grove-road, Ladbroke-grove, Lancaster-road (part of),

Lansdowne-road, Lansdowne-crescent, Norland-square, Oxford-gardens, Portobello road (part of), Powis square, Royal crescent, St. Charles-square, St. Mark's-road, Uxbridge-road. The total length of street in which mains should be laid along both sides is about 4·6 miles, and along one side only is about 1·4 miles. Total, about six miles of street.

In the following list of totals the shops and private houses in those streets are again distinguished and grouped, and under an estimate of the number of lights each might be expected to require a possible total of 40,390 8 c.p. incandescent lamps that may be eventually installed, is obtained:

Houses.

204 under	£50 rating, each	10 lights	....	2,040	
773 ,,	£100 ,, ,,	20 ,,	....	15,460	
289 ,,	£150 ,, ,,	35 ,,	....	10,115	
38 ,,	£250 ,, ,,	60 ,,	....	2,280	
6 over	£250 ,, ,,	100 ,,	....	600	
					30,495

Shops.

25 under	£50 rating, each	15 lights	....	375	
117 ,,	£100 ,, ,,	30 ,,	....	3,510	
59 ,,	£150 ,, ,,	50 ,,	....	2,950	
14 ,,	£250 ,, ,,	90 ,,	....	1,260	
12 over	£250 ,, ,,	150 ,,	....	1,800	
					9,895
	Total		....		40,390

The analysis of the above from metropolitan and other experience and results, and in view of the increased opportunities and inducements we have mentioned, permit an estimate of the probable number of lights that will be joined up during the first three years at:

One-fourth of 30,496 = 7,623
One third of 9,895 = 3,298

10,921

Of these we calculate that in houses $\frac{5}{7}$ths = 5,445, and in shops $\frac{6}{7}$ths = 2,826, will be in use at one time, giving a total for which plant should be provided of = 8,271.

These figures indicate that the minimum capacity of the installation to be put in hand for the supply of private lighting should be for 8,500 8-c.p. lamps in use at one time, which at 33 watts per lamp at the terminals, and 35 at the station, requires a plant that without spares should have a capacity of output of 300 kilowatts.

For public lighting of main thoroughfares two routes are plainly indicated as capable in the first instance of being supplied from a station at Kensal Wharf—namely, first, Ladbroke grove and Ladbroke grove road, lying north and south, and second, the Uxbridge-road from Norland road on the west to Kensington Gardens on the east—the united length of thoroughfare being about 2¼ miles. As regards this service of public lighting, if the Vestry desires to undertake it, and on economical grounds there are good reasons why they should do so, there are no difficulties and it can be done in conjunction with the private supply in Districts 1 and 2, and independent of the private lighting in part of District No. 3 now served by the Notting Hill Electric Light Company. This 2¼ miles, assuming that arc lamps giving the same light as those used in the City of London, are employed, and that these are placed at an average of about 70 yards apart, or 25 to the mile, will require about 63 kilowatts, raising the total capacity of the station to be first equipped to 363 kilowatts without spares.

Including spares, therefore, we are of opinion that the equipment of the station available for distribution should not be less than 500 e.h.p.

In estimating the cost of an installation system of the above-named size, it is usual to name a figure per electrical horse power which will cover everything, and in this case we estimate that figure at £75, which, for 500 e.h.p. gives £37,500. Following the same system, and taking into consideration the extended area over which supply has to be given, this total divides itself as follows:

22 per cent. for land and buildings	£8,250
30 per cent. for the equipment of the station	11,250
40 per cent. for the work in the streets	15,000
8 per cent. for contingencies (including provision to cover losses while first running the supply, say, for one year).	3,000
	£37,500

But in this case the item for land and buildings may be reduced, and it would be safe, owing to the fact that the fuel and stoking will not be a charge on the electric generation, also to reduce the estimate of contingencies by £1,000.

Our estimates under the circumstances may then be taken as follows:

Destructor, land, chimney, etc.	£8,680
Electric light buildings, etc	2,800
Equipment of the electric light station, including boilers.	11,250
Distribution, etc.	15,000
Contingencies	2,000
	£39,730

of which £31,050 is required for electric light.

This expenditure on electric light may be allotted in the following proportions to public and private lighting—viz.:

One-sixth to public = £5,175
Five-sixths to private = 25,875

Total £31,050

The annual charges on the debtor and creditor sides for the electric lighting alone, without combining it with the destruction of refuse, are as follows:

Debtor.

Interest and redemption at 4½ per cent. on £31,000	£1,395
Works cost at 2·95d. on 253,024 units, made for public and private lighting	3,110
Office and management and collection	500
Depreciation	832
Attendance and trimming 63 arc lamps	300
	£6,137

Creditor.

Value of 133,224 units, 12 units to each private lamp and 24 units to each shop lamp per annum nearly 8¼d. a unit	£4,577
Value of 63 arc lamps (nominal 2,000 c.p.) at £20	1,260
Public gas lamps discontinued	300
	£6,137

showing that if sold at cost price to the Vestry, 8¼d. a unit would have to be charged for the electricity.

The following is a similar statement for the destruction of refuse alone:

Debtor.

3½ per cent. on £8,680 cost of destructor	£390
Depreciation and repairs 3½ per cent.	304
Superintendence working, £20 a week	1,040
Clinker, ashes, etc., remaining on 25,000 tons of refuse, 8,250 tons, including lifting, 3s.	1,237
	£2,971
Saving	570
	£3,541

Creditor.

Barging at present rates 25,000 tons at 2s. 10d. from Kensal Wharf.	3,541
	£3,541

Lastly, follows a statement showing that the price at which the Vestry could sell electricity if the two are combined might even be as low as 4½d. per Board of Trade unit.

Debtor.

Interest and redemption on (£31,000—£8,680) £39,680 at 4½ per cent.	£1,785
Depreciation £832 + £304	1,136
Superintendence and working of destructors, boilers, and plant	1,040
Electrical works cost, less coal and stoking, at 1·48d. per unit made	1,556
Office management and collection	500
Removal and lifting remains of refuse	1,237
Trimming and attendance arc lamps	300
	£7,554

Creditor.

Saving on barging	£3,541
Public lighting	1,260
Private light, at about 4½d. per unit.	2,453
Public gas lamps discontinued	300
	£7,554

The above shows that if the Vestry sells electricity at 5½d. a unit to private consumers, as soon as the station is nearly fully occupied, there could be made a profit in favour of the ratepayers of about £550 a year. We have been careful in the above estimates not to minimise the charges on the debtor side, and it is clear that when the demand for current justifies an increase of the generating plant, the results will be very much better.

As regards the questions which the committee require us to answer, we believe that the above results fully justify us in giving an affirmative to each, and also in recommending the Vestry to proceed without delay for powers under a provisional order to deal with the whole parish: after which it will be time enough to give instructions for the detailed plans, estimates, and specifications to be put in hand. For reasons already mentioned, we should suggest that except for public lighting, and where the existing companies fail to give a supply, the Vestry may let the Board of Trade understand that for the present they propose to confine their operations to Districts 1 and 2.

In conclusion, we wish again to point out that the figures we have given show that any report which dealt with the question of the supply of the whole parish in a manner adequate to the future maximum demand, means that an expenditure of over half a million would have to be considered, and that then the annual economy on the working due to the use of house refuse as a fuel for generating steam, would affect but a small fraction of the total running costs. Such a report might have besides to deal with questions connected with the acquisition by purchase of the undertakings of the existing electric light companies, whether that acquisition took place at an early date, or was deferred to the end of the statutory period of 42 years. Throughout the provinces the local authorities are everywhere becoming the undertakers under the Electric Lighting Acts, and there are already examples of it in the Metropolis. The commercial considerations must be weighed equally whether the supply is by a private or public body, and it requires the lapse of some little time longer to show whether the latter can deal successfully with the question, apart from the exceptional advantages afforded, as in the case presented by this report, through the utilisation of the house refuse.

COMPANIES' MEETINGS.

ELECTRIC CONSTRUCTION COMPANY, LIMITED.

The statutory meeting of this Company was held yesterday at the Cannon street Hotel under the presidency of Sir Daniel Cooper, Bart., chairman of the Company.

The **Chairman** stated that the meeting had been called in compliance with the provisions of the Limited Liability Acts, and that they had no formal business to submit. He was happy to inform them that the reconstruction of the old company into the new had been carried out with complete success. They had applied to the Stock Exchange for a quotation for the new shares, and as they had supplied the committee with full and, he believed, satisfactory information on all points, they hoped that the quotation might soon be granted. They had succeeded in re-establishing the credit of the Company, and were in consequence able to do business on more advantageous terms than was possible in recent years. They had, therefore, every reason to expect that they would be able next autumn to submit a satisfactory report of the year's transactions. Since their last meeting the Board had been strengthened by the addition of Mr Philip E. Beachcroft, who represented the trustees of the first mortgage debentures, and also large holders of shares. He then called upon the Managing Director to address them.

Mr E. Garcke said that it was unnecessary for him to take up much time, as it was only four months ago that he made a full statement of the affairs of the Company. When he addressed them as shareholders of the old company on the 5th July, he explained in some detail the financial position of the Company and gave a description of the various assets. He mentioned on that occasion that there was much to be done before they could be in a thoroughly sound commercial and financial position, and that many of their investments were of such a character that if properly developed, promised not only to become more valuable, but also have the effect of largely increasing the business of the Company. He had also remarked prior to the reconstruction that the Company was suffering both in name and in credit, that they had difficulties in competing fairly with others, and that they did not get the full benefit of what they were doing. He likewise explained that if the reconstruction was carried, the prospects in these respects might be expected to improve. He then proceeded to indicate how far those anticipations had been realised in the four months that had elapsed. The financial position, he observed, had greatly improved. They had taken steps to realise some of the securities in which so much money was locked up, and the credit of the Company now stood on a firmer basis. Those changes could only be accomplished slowly, and four months were not long to do much in such matters, but as long as their progress was sure and on a right line, the shareholders ought not to complain. The business was taken over from the old company from the 1st July last. Since then they had not done badly in the matter of orders notwithstanding the general depression in trade. Their orders, he believed, were fully up to the average of previous years, and they ought to have a satisfactory profit upon them, but until their books were closed, he could not, of course, speak with certainty as to the result of work which was still in course of execution. In discussing this question of profit, it must not be forgotten that they had very extensive works equipped for carrying out more extensive orders than they had yet obtained, and they all knew that when factories were only partially employed, the work was not so economically done as when the plant and staff were working at their full capacity, for the standing charges and administration were the same whether much or little work was done. With regard to various subsidiary companies, in which so much capital was locked up, their policy had been to assist them into a sound position, and to do that without prejudicing the parent company, and without adding to their responsibilities, as their policy was to liquidate outstanding liabilities and to reduce their responsibilities. The Company looked forward with much hope to the development of electric traction, and their investments in this direction would help them to do further business. The work which they had done in the field of traction in South Staffordshire, Liverpool, and in other places, was the best recommendation they could have. Numerous engineers and representatives of local authorities had inspected their work, with the result that they had secured some contracts and were negotiating for several others. They had acted as pioneers in electric traction in this country and they were in a position to undertake and carry out successfully large contracts of this kind. A company had been formed in America to manufacture electrical apparatus of their design. They had not put any cash into the company but the latter had agreed to make their machinery, and in consideration for this they would assign to the Electric Construction Company an interest in the American Company. With regard to electro-chemistry, their views of which he expressed at the last meeting, they were now negotiating for working some of the patents in which they were interested, and in which they fully fully believed. In other branches they were getting their fair share of orders. He believed the Company's technical work was sound and without reproach. The working of the overhead railway at Liverpool was a revelation to electrical engineers, and the economy with which they were running the cars in South Staffordshire would suggest a new future for many tramways which were now working with horses and steam but without dividends. The Company would do all they could to develop the business, and they would not accept contracts unless they saw that they would yield a fair profit. He concluded by expressing his belief that with careful management and strict economy they might reasonably expect to have a prosperous future before them.

This terminated the business of the meeting.

An extraordinary general meeting was then held, when the following resolutions, in order to comply with the requirements of the Stock Exchange, were passed:

"1. That Article 60 of the articles of association of the Company be amended by substituting the words 'one tenth' for the words 'one fifth' in the fourth line thereof." The article will then read: "The Directors shall call an extraordinary meeting whenever a requisition in writing, signed by not less than one twentieth in number of the members of the Company, holders in the aggregate of not less than one tenth in amount of the capital then issued and paid up, and stating fully the general nature of the business for which the meeting is proposed to be called, shall be delivered to the Secretary, or left at or sent by post to the office."

"2. That Article 135 of the articles of association of the Company be amended by adding at the end of the article the words 'and a copy of such balance sheet and report shall be sent out, seven days previous to the general meeting, to those shareholders entitled to receive the same.'" The article will then read: "Once at the least in every year the Directors shall lay before the Company in general meeting a proper balance sheet and profit and loss account for the past year, made up to a date not more than four months before such meeting, and a copy of such balance sheet and report shall be sent out, seven days previous to the general meeting, to those shareholders entitled to receive the same."

WEST INDIA AND PANAMA TELEGRAPH COMPANY.

The thirty third ordinary general meeting of this Company was held on Wednesday at Winchester House.

The **Chairman** (Mr. C. W. Earle), in moving the adoption of the report, referred to the death of his colleague, Mr Henry Weaver, who was elected to a seat on the Board by a committee of shareholders nearly 20 years ago, and stated that the vacancy had been filled by the appointment of Mr. G. W. Balfour, M.P. He thought they might congratulate themselves on having had, for a West Indian company, rather a satisfactory half year. The normal traffic increased somewhat from the great reduction that occurred owing to the reduced rates forced upon the Company in 1891. In consequence of the breakdown of the cable of their competitor, the French Cable Company—the whole traffic of that line came upon this company's line at Martinique, and during the seven weeks they were interrupted they had an increase in traffic of about £2,800. The expenses of repairs to cable amounted to £10,720, being £12,358 less than those for the corresponding period. This decrease was due to fewer repairs and to the smaller quantity of cable used. The Directors, desiring to recognise the long and faithful services of some of the employés and to strengthen the good relations which existed between the Company and its staff, proposed to offer to bear one half the expenses of life or endowment insurances for some of those who had been in the Company's service a certain number of years. He could not say what the expense would be, but the saving effected by not filling up two vacancies on the Board would leave a good margin. The Board proposed to pay dividends of 6s. per share on the first and second preference shares respectively, and 1s. per share on the ordinary.

Mr. W. Andrews seconded the resolution, which was adopted.

LEGAL INTELLIGENCE.

THOMPSON v. COWLES SYNDICATE, LIMITED.

In the Queen's Bench Division on Tuesday, Baron Pollock gave judgment in this case, to which reference was made in our last issue. The case, his Lordship said, was somewhat intricate, and was commercially important. The action was to recover the price of 10,104 carbon smelting rods, the greater part of which had been rejected by the defendants on the ground that they had not been supplied according to warranty, and as to a small portion of the rods which they admitted to be of good quality, they paid a sum of money into Court. Now, he held that on the point of warranty the defendants must fail. It was quite clear to his Lordship that there was no warranty. The process of the manufacture of aluminium by electric smelting was a somewhat new one, and was not generally known—in fact, it appeared to be known to a few persons only, though the manufacture was carried on to some considerable extent by one firm in Switzerland. The process, therefore, could not be said to be known to the plaintiff except in the most general form, but upon reading the correspondence for more than a year between the plaintiff and the Paris manufacturer, M. Berne, and the defendants, and also from the evidence, he came to the conclusion that carbon rods, both for electric lighting and smelting purposes, were generally known in commerce, and that being so, the intention of the parties to the contract was immaterial. There was no warranty, and the only question was whether the defendants were entitled to reject the larger part of the carbons supplied on the ground that they were not of the commercial quality which they ought to have been as such goods were known in the trade—not because they were unsuited to any particular and general unknown process—but because they were not good marketable commercial carbons applicable to commonly known purposes. Having minutely examined the correspondence and the evidence his Lordship

came to the conclusion that the carbons supplied were of two different qualities, and that those rejected by the defendants were not of good marketable commercial quality. The evidence, which had been given very fairly on both sides, showed that the condition of the furnaces or crucibles containing the molten metal was the same when the defective carbons were used as when the good carbons were used, leaving the only inference that the beating and wasting of the carbon rods was due either to a defect in the manufacture or in the materials of the carbons. His verdict and judgment would therefore be for the defendants on the claim, with costs. With regard to the counter claim by the defendants for special damages for breach of warranty, it must fail, as he had held that there was no warranty. Judgment would therefore be for the plaintiff on the counter-claim.

Mr. Tindal Atkinson, in view of the important principle involved in the case, asked on behalf of the plaintiff for leave to appeal, which his Lordship granted on condition that £100 shall be paid into court within a week.

ELIESON ACCUMULATOR (BRITISH PATENT) SYNDICATE, LIMITED, v. THE EARL OF GALLOWAY.

In the Queen's Bench Division, before Mr. Justice Kennedy, sitting without a jury, an action was brought by the Elieson Accumulator (British Patent) Syndicate, Limited, against the Earl of Galloway to recover the sum of £400, alleged to be the amount due on the allotment of shares held by the defendant in the plaintiff company. The defendant put in numerous defences, the effect being that the application for shares was made without his consent or authority. The case for the plaintiffs was that on August 10, 1892, the defendant applied in writing, addressed to the secretary of the Electric Storage and Traction Syndicate, for 100 shares of £10 each, and enclosing a cheque for £50, being a deposit of 10s. per share. He handed the letter and application to a Mr. Watson Smith for the purpose of enabling Smith to procure an allotment. At the same time he told Smith that he would pay the balance of £950 within three months from the date of application. He further agreed with Smith that he would take 1,000 shares of £1 each in the plaintiff company, and he authorised Smith to procure such an allotment. On August 24, in pursuance of such agreement, the defendant wrote to Smith, enclosing a cheque for £50 as a deposit of 1s. per share. He subsequently asked Smith to transfer and treat his application for 100 shares in the Electric Storage and Traction Syndicate as an application for an additional 1,000 shares in the Elieson Syndicate.

After hearing evidence his Lordship reserved judgment, which is to be delivered on Monday next.

BUSINESS NOTES.

Coventry.—A supply of the electric light will be in operation by June next.

Conisborough.—It is stated that the works of Messrs. Kilner Bros. are to be lighted by electricity.

Western and Brazilian Telegraph Company.—The receipts for the week ended November 10 were £3,316.

Londonderry.—Messrs. Alex. Brown and Son, of Derry, have received the contract for supplying lamp pillars at £9 each to the Corporation.

Portobello.—The Town Council have remitted to a committee to enquire into the question of public lighting and all available sources of supply.

Ilfracombe.—The Ilfracombe Local Board has decided that seven electric bells shall be provided for summoning the fire brigade in case of fire.

Bury.—Aldermen Brierley and Parks, Councillors Butcher, Collinge, Byrom, Hopkinson and Thornley have been elected as the Electric Lighting Committee.

Ipswich Electricity Supply.—The petition for the winding-up of the Ipswich Electricity Supply Company, Limited, referred to in previous issues, has been struck out of the list.

Chichester.—A report on the cost of lighting the town by electricity has been submitted to the sub-committee of the Lighting Committee of the Town Council by Councillor Prior.

Canterbury.—The Town Council have made an order to affix the corporate seal to the deed of transfer of the Canterbury Electric Lighting Order, 1891, to the Canterbury Electricity Supply Company, Limited.

Normanton.—A discussion has taken place at a meeting of the Local Board as to what can be done in the way of lighting the public streets cheaper and better, but not a word was mentioned of the electric light scheme about which enquiries were made two months ago.

City and South London Railway Company.—The receipts for the week ending November 12 were £909, against £945 for the same period last year, or a decrease of £36. The total receipts for the second half year of 1893 show an increase of £201 over those for the corresponding period of 1892.

The Way to Do Business.—We cull the following from the *Blackpool Gazette*: "Several large deputations have visited Blackpool lately to inspect the new electricity works, and arrangements are being made for others in the early future. On these occasions hospitality is very freely dispensed by Mr. Robert Hammond.".

Swansea.—A scheme is on foot for the establishment in the neighbourhood of Landore of new large works for the electrical deposition of copper and other metals. The matter has not yet assumed a definite form, but it is being discussed by some of the wealthiest and most important people engaged in the metal trades.

Amalgamation.—The firms of Messrs. Theiler and Sons, of Canonbury, and Messrs. Elliott Bros., of St. Martin's lane, are amalgamating under the title of Messrs. Elliott Bros. Mr. G. K. B. Elphinstone, the representative of Messrs. Theiler and Sons, and Mr. W. Smith, the chief of Messrs. Elliott Bros., will be co-partners.

William Banks and Co., Limited.—This Company has been registered with a capital of £4,000 in £5 shares to acquire and carry on the business of opticians, mechanical and electrical engineers, and manufacturers of photographic apparatus hitherto carried on at 32, Corporation-street, Bolton, under the style of William Banks and Co.

Rotherham.—Major Hirst, in seconding the motion for the election of the mayor the other day, observed that it was time the town had better light. The best thing they could do was to go into the subject of electric light. If it was established in the borough it would not only reflect light, but credit on those who had undertaken the work.

Wigan.—The following gentlemen have been appointed as the Gas and Electric Lighting Committee of the Town Council: Messrs. Ackerley, Benson, Booth, Millington, Henderson, Hilton, Riley, John Johnson, Richards, J. Woods, Riddlesworth, Rigby, Smith, Ashton, Richard Johnson, C. B. Holmes (chairman), and John Gee (vice chairman).

Newcastle.—The Corlett Electrical Engineering Company, Limited, having head offices at Wigan, has opened a branch establishment at Newcastle-on-Tyne. This will be under the management of Mr. C. W. Fairweather, who for the past few years has been works manager for Messrs. Ernest Scott and Mountain, Limited, Newcastle-on-Tyne.

Southend.—The Town Council, according to the Pier Committee's report, intend to keep the electric light and tramcar plant in good order, and the committee will arrange with Messrs. Crompton and Co., Limited, to make five inspections over next 12 months—one at once, another immediately before the commencement of next season's running, and three others during the season—for the sum of £25.

Grimsby.—The Town Council, to whose proceedings in connection with electric lighting we referred in our last two issues, held a meeting on the 10th inst. to authorise the application for a provisional order. The Mayor explained that that was a statutory meeting, according to the Act of Parliament, one month's notice having been given, and he therefore moved the authorisation of the application. Mr. Jeffs seconded the motion, which was carried unanimously.

Lee Lamp (Parent) Company, Limited.—This Company has been registered with a capital of £50,000 in £1 shares to carry into effect an agreement made between J. Hodgson Lee and this Company, and to carry on the businesses of manufacturers of and dealers in lamps for lighting, heating, etc., by the agency of oil, gas, electricity, or other means. The first signatories are C. F. H. H. Bagot, W. J. B. Chetwynd, C. M. E. Wynne, T. Kaye, R. P. Lee, T. J. Crawley, J. Goodman.

Portsmouth.—A certificate, presented by Messrs. Waller and Manville, for payment to the contractors for conduits, etc., in connection with the electric light, to the amount of £1,900, was ordered to be paid by the Town Council last week. The following were appointed as the Electric Lighting Committee: The Mayor, Aldermen Ellis, Scott Foster, Cudlipp; Councillors Beale, Ashdowne, Avens, Dean, H. Kimber, F. G. Foster, Croucher, Dittman, Corke, Ross, Bamber, Fulljames, Dummer.

Falmouth.—The Town Council, after receiving the report of Messrs. Veale and Co. on the electric lighting of the town, passed the following resolution: "That the chairman and members of the Lighting Committee be thanked for the services they have rendered in obtaining so much valuable information in the matter of lighting Falmouth with electric light, and that they be invited to communicate with the gas company, or any person, with a view to obtaining further information on the subject."

Wakefield.—Councillor Walter Wade, the new mayor, promised on his election to give his attention to the extension of the waterworks, the sewage works, and the proposal to introduce the electric light, and he expressed a hope that certain street improvements would be carried out. The Mayor, Alderman Carter, Councillors Booth, Hall, Harrison, Haslegrave, W. Moorhouse, Nicholson, Rhodes, Saville, Smith, and Stonehouse have been appointed members of the Electric Lighting Committee.

Tunbridge Wells.—As mentioned in our last issue, the Corporation have decided to spend £13,000 on electric lighting, and now a Local Government Board enquiry on the subject has been held. The Town Clerk stated that they did not at first propose to go in for the entire substitution of electricity for gas, but only for a part of the borough as an experiment. A site for the electric light station has been secured near the Grosvenor Bridge, close to the South-Eastern Railway. It is proposed to adopt the high-pressure system.

Tiverton.—An arc lamp of 1,500 c.p., outside Ford's Brewery, Tiverton, was lighted for the first time last week. When a large portion of the brewery was destroyed by fire some time ago, Messrs. Ford and Son determined to substitute electric light for gas. During the last two months Messrs. Stenner and Co., engineers, Tiverton, have been supplying and fitting the necessary

plant. An 11-h p. turbine fixed in a leat running into the Lowman drives the generating dynamo. There are 100 16 c.p. lamps on the premises.

Crieff.—Some time ago a proposal was brought before the Crieff Town Council for the introduction of the electric light into the town. Since then, Sir Patrick Keith Murray, Bart., of Ochtertyre has offered the use of the Falls of Barvick, two miles from the town, to be utilised for the motive power for generating the current, and at a meeting of the Council on Monday, Provost Adie urged upon the Board to take advantage of Sir Patrick's offer, and stated that he would shortly lay before the Board a scheme for this purpose.

Derby.—The Electric Lighting Committee, at a meeting of the Town Council last week, applied for a further £5,000 to extend the mains from the top of Traffic-street to the Midland Station, through Friar-gate to Vernon-street, and for laying down a 200 h.p. engine. Mr. Marsden moved a resolution to this effect. Alderman Newbold strongly opposed the grant of more money upon an experiment. Sir A. Haslam also opposed the proposal. Several other members having spoken in favour of the motion, it was carried by a majority.

New Installations at Richmond.—We hear that Mr. C. A. Hemingway, of 10, Petersham-road, Richmond, is carrying out an installation at the establishment of Mr. John Cockburn, jeweller, etc., George-street, Richmond, Surrey, where 60 lamps of 16 c.p. are being fitted. Mr. Hemingway has also carried out installations at Mr. T. J. Palmer's, chemist; Mr. G. H. Young's, wine merchant; Mr. Arthur Greeves's, hatter, etc.—all of George-street. Mr. Young's was the first shop in Richmond to be lighted by the electric light.

Dover.—The surveyor reported, at a meeting of the Town Council last week, that the telephone company were willing to connect the drainage works with his residence for £9, but he thought, considering the many facilities that they had obtained from the Corporation, better terms should be made. Alderman Peake moved that the total amount paid to the telephone company by the Corporation be ascertained. He thought they should get something in exchange for what they gave the telephone company. A report was ordered to be prepared.

Phosphor Bronze.—The Phosphor Bronze Company, Limited, of 87, Sumner-street, Southwark, S.E., inform us that they have appointed Messrs. Dempster Moore and Co., of 49, Robertson-street, Glasgow, as their sole agents in Glasgow for the sale of their manufactures—namely, phosphor bronze alloys, Duro metal (for bearings), plastic metal and white brass Babbitt's and other white anti-friction metals, Bull's metals for propellers, forgings, and stampings, manganese bronze, phosphor tin and phosphor copper. A small stock of some of these metals will be kept at the agents' warehouse, 49, Robertson-street, Glasgow.

Transmission of Power.—The Moodie Gold Mining and Exploration Company, of South Africa, have now concluded contracts with Messrs. W. T. Goolden and Co., of Woodfield Works, Harrow-road, London, W., for the supply and erection of plant for the electrical transmission of 250 h.p. generated by water power of the Queens River, to the various mines situated near Barberton, a distance of about 10 miles. This is the most important power-transmission scheme yet undertaken in South Africa, and if successfully carried out must have an important bearing on the future of some of the South African gold mines.

Tenders for Dublin.—The Corporation invite, on or before 14th December, tenders for the extension of the buildings, and the supply and erection of additional plant at the central station, Fleet-street, Dublin. Plans may be seen and specifications and forms of tender obtained at the office of Mr. Spencer Harty, C.E., city surveyor, City Hall, Dublin, on payment of one guinea, which will be returned to all persons sending in a *bona fide* tender. Tenders to be enclosed in a sealed envelope, addressed and forwarded to the Town Clerk, City Hall, Dublin, and endorsed "Tender for the Extension of Buildings at the Electric Lighting Station," or "Tender for the Supply of Electric Lighting Plant," as the case may be.

Ramsbottom.—The chairman of the Local Board moved at a meeting of that authority that they should write to the Board of Trade for provisional powers for lighting Ramsbottom by electricity. Mr. Barlow seconded the motion. The Chairman said he had been in communication with a firm of electrical engineers, and they had satisfied him that the work could be done cheaply. He could not give them any particulars, but at any time if any member wanted to know, he (the chairman) would give them particulars as to quantity, cost, etc. He would inform them where it was proposed to fix the plant, how many "arc" lights there would be needed for lighting the main streets, and what preparation would be required for incandescent lamps for supplying shops and mills. The resolution was adopted.

York.—On the consideration of the Streets and Buildings Committee's report, at a meeting of the Council on Wednesday, a long discussion took place on the action of the members of that committee who had visited Scarborough and Huddersfield for the purpose of inspecting the Parsons system and the Brush system of electric lighting. Four firms had contracted for the electric lighting of the city, and it was urged that the committee ought not to have visited these towns at the invitation of two of the contractors, and allowed them to pay the railway fare and entertain members of the committee to dinner during their visit. A resolution was passed stating, that whilst the Council fully acquitted the Streets Committee of any irregularity, the Council was of opinion that the expenses of its committees on city business should be defrayed out of the rates of the city.

Camberwell.—The Vestry have adhered to their previous resolutions requiring the wires for fire alarms at Dulwich to be placed underground. At a meeting of the Vestry last week, Mr. E. R. Phillips, chairman of the Electricity Committee, presented a report with reference to the proposed application for a provisional order to establish electric lighting in the parish. The committee recommended "That the Vestry approve the following streets—viz., Camberwell-road, Camberwell-green, Church-street, Peckham-road, High-street, Peckham, Queen's-road, Peckham (from High-street to railway station) Rye-lane, and Old Kent-road—as being streets through which distributing mains for general supply are to be laid within two years from the commencement of the order." The recommendation was adopted.

Taunton.—The Electric Lighting Committee of the Town Council reported last week that they had engaged for 12 months (through the Electrical Standardising Institution) the services of Mr. A. J. Howard as an improver, upon payment by him of the sum of £50. The committee were unable to report upon the proposed extension of the electric lighting works owing to Dr. Fleming not having sent his report, but they hoped to be able to report fully thereon at the next Council meeting. Alderman Standfast expressed surprise that the report of Dr. Fleming was not forthcoming, especially as he understood that the cable was carried to Mr. Steevens's place on the strength of what that report said. The following were appointed as the Electric Lighting Committee: Alderman Chapman, Councillors Hartnell, Sibley, Goldsmith, Steevens, Potter, A. Goodman, and Hammett.

Cheltenham.—On Wednesday an enquiry was held by Colonel Hasted, R.E., Local Government Board inspector, at Cheltenham, into the application by the Corporation for leave to borrow £16,000 for the purpose of electric lighting in the borough. Mr. Brydges (town clerk) called Mr. Norman, who described the various steps taken in the matter by the Electric Lighting Committee, of which he had been chairman up till November 1. The borough surveyor (Mr. J. Hall, C.E.) afterwards gave estimates, and explained the scheme of lighting, which is to be the alternate-current system, as recommended by Profs. Ayrton and Preece. Two or three ratepayers were heard in opposition, and the enquiry closed. The Mayor, Aldermen Griffith and Thoyts, Councillors King, Lawrence, Parsonage, Ward-Humphreys, and Woodard have been elected members of the Electric Light Committee of the Town Council.

Douglas and Laxey Coast Electric Tramway.—As mentioned in our last issue, tenders are invited for the extension to Laxey of the existing line from Douglas to Groudle Glen. The works to be tendered for are in two sections, numbered 2 and 3. Section No. 2 comprises a roadway 2,200 yards in length, and about 40ft. wide, and laying a 3ft. gauge railway line on one side; it also includes a masonry bridge, 50ft. high, with three 20ft. spans, and a culvert, 100ft. long, 7ft. span, and 13ft. high. Section No. 3 comprises the formation and laying of a railway line, 3ft. gauge, and about 6,000 yards long—rails, sleepers, fastenings, electric plant, and rolling-stock are not included. Plans can be seen at the office of Mr. F. Saunderson, C.E., Athol-street, Douglas, Isle of Man, and specifications, quantities, and forms of tender obtained upon payment of two guineas, which will be returned on receipt of a bona fide tender. Tenders to be delivered at the office of Douglas and Laxey Coast Electric Tramway, Limited, 7, Athol-street, Douglas, Isle of Man, by 25th inst.

Wolverhampton.—It is proposed to erect some extensive engineering and electrical works at Wolverhampton. The Town Council have already sanctioned an application for the rails from the Midland goods station to be laid across the Wednesfield-road to land on the opposite side of the road, which will be the site of the proposed works, and a railway siding will be provided. The site consists of between three and four acres of vacant land, which is level, and will form a suitable position. The works will be adjacent not only to the Midland goods depôt, but in close proximity to the main line of the Great Western Railway Company. The only works of the kind in the neighbourhood are those of the Electric Construction Company at Bushbury. The new Mayor, speaking after his election last week, said, with regard to the electric lighting scheme, that the land had been bought for the station; that the committee had enquired thoroughly into the matter; and that he thought he might safely say that before next winter they would have a plant second to none for its size in the kingdom.

Halifax.—On the proposal of the names suggested for the Gasworks and Electric Lighting Committee—the names being Aldermen Brear, E. Robinson, Patchett, Councillors Beever, Hodgson, Braithwaite, Woodhead, T. Greenwood, Rushworth, Dr. Smith, W. H. Spencer, I. Firth, and Hartley—Alderman Patchett proceeded to explain that he desired to make the number on this committee 16, and that out of it should be formed the Electric Lighting Committee. The additional names he proposed were Alderman Brook, Councillors G. H. Smith, Butler, Wade, and Bunney, and leaving off the committee suggested Dr. Smith and W. H. Spencer. The ex-Mayor seconded this. Councillor Woodhead objected to the proposal on the ground that the motion would interfere with the equal representation of the wards, four having double the allowance of the rest. He thought the Electric Lighting Committee, considering that they were proposing to spend £30,000, should be a separate committee, consisting of not less than 12 members, each ward to have equal representation. For the amendment there voted 24 members, and 16 against.

Poole.—A meeting of inhabitants of Poole, Parkstone, and Bournemouth has been held at the Poole offices of Mr. F. G. Wheatley, mayor of the borough, to discuss a proposal with regard to the

construction of an electric tramway between Poole and the County Gates, Bournemouth; and also for the supply of the electric light to Poole, Parkstone, and a large part of the district lying between those places and Bournemouth. Powers have already been obtained from the Board of Trade for the carrying out of these undertakings; but the question has arisen whether it would not be more economical to amalgamate the two schemes under one management. The schemes were received with considerable favour. Mr. Gordon Smith made a statement with regard to the character and cost and probable success of the undertakings, and a resolution was carried pledging that the inhabitants of Poole, Parkstone, Bournemouth, and district should do everything to facilitate the carrying through of the scheme for laying down electric tramways between Poole and Bournemouth, and the electric lighting of the town and district of Poole. Mr C Bastin, Amesbury Villa, Serpentine-road, Poole, has the schemes in hand.

Colliery Lighting.—Messrs. Ernest Scott and Mountain, Limited, of Newcastle, have received an order from the Coltness Iron Company, Newmains, Lanarkshire, for an electric light installation for their colliery, and which will be one of the most complete plants in existence. The plant consists of a complete electric light installation for the colliery, consisting of dynamo to run 200 16 c.p. lamps, and about 180 lamps throughout the pit, both above ground and underground. The second is an installation for the lighting of 34 workmen's cottages, which are about 200 yards from the colliery, there being three lights placed in each cottage, or a total of 102 lamps in all. The third installation consists of a complete electric pumping plant capable of delivering 100 gallons of water per minute from the river to the colliery. The dynamos for the lighting of the pit and workmen's cottages are being specially constructed, so that either dynamo can be utilised for either purpose, both machines being over-compounded, so that the E.M.F. will remain constant at the cottages under variations of load. This installation is probably one of the first in which complete plant for pumping, lighting of a colliery, and the lighting of workmen's cottages has been adopted.

Result of Tenders.—The following tenders have been received for the construction of chimney shaft at the East St. Pancras central station, King's-road, N.W., for the Vestry of St. Pancras:

Burman and Son, Delauno Works, Kennington	£5,718
Jerrard, 40, Loampit-vale, Lewisham	4,800
Spencer and Co., 32, Commercial road, Lambeth	4,676
H. Wall and Co., Carlton-road, N.W.	4,650
Godson and Son, Pembroke Works, Kilburn	4,567
C. Wall, Lots road, Chelsea	4,450
Mowlem and Co., Grosvenor Wharf, S.W.	4,421
Holden and Myles, Stalybridge	4,168
Smart, Trent Bridge, Nottingham	4,094
J. E. Johnson and Son, Leicester	3,860
J. Stead, Chalk Farm road	3,854
Kellett and Co., Willesden	3,557
Kelly Bros., Liverpool	3,437
W. Neil, 165, Turners road, Burdett-road	3,332
J. Yates and Co., Hollybrook-road, Ratcliff	3,100

The tender of Messrs. Yates and Co. having been withdrawn, that of Mr. Neil, for £3,332, has been accepted.

Tullie House at Carlisle.—The Institute of Literature, Science, and Art established by the Corporation of Carlisle at Tullie House has been formally opened. The scheme for the introduction of the electric light was prepared by Mr. Howard Smith, the city surveyor and architect of the new building, and was carried out under his supervision. The dynamo and engine room is located in the basement of the building. The engines are duplicates, and have been supplied by Messrs. Tangyes, of Birmingham. They are each of 16 nominal horse power, but are capable of developing 35 h.p. The engines run at a speed of 160 revolutions per minute, and drive the dynamos at a rate of 600 revolutions per minute, giving an E.M.F. of from 100 to 105 volts, and producing 200 amperes. The dynamos are two in number. The current from the dynamos is conducted to a main switchboard, where it is divided into seven circuits. The lamps which have been supplied are the Edison Swan incandescent type, and number altogether throughout the building close upon 420, varying from 8 c.p. to 32 c.p. and 50 c.p., and giving an equivalent of 566 of 16 c.p. lamps. The dynamos and electrical apparatus and lamps have been erected by Messrs. Latimer Clark, Muirhead, and Co., of Westminster, the contractors for the whole of the electrical work, which has been carried out by Mr. W. E. Weiss, their representative. The engines and dynamos, as well as the heating apparatus, are under the charge of Mr. Tom Duckworth.

Blackpool.—The Markets and Gas Committee recommended, at a meeting of the Town Council last week, that the gas manager should be authorised to utilise as much of the old electric lighting plant in the town's yard, Victoria street, for gas purposes as may be available, and to sell any plant not required; also to remove all electric light posts not now required for electric lighting purposes on the Promenade. Mr. Alderman Cocker moved that both these recommendations be referred back. He asked where was the gas manager to use the plant; and whether the gas manager should interfere with the electric light? It had never been decided that the old lights should be done away with, and they could talk as they liked about the superiority of the new lamps, but it was worth Blackpool's while to pay for the old lamps to be retained, even though for advertising purposes only. Mr. Councillor Dickinson said that he would second the amendment as applying to the posts, for they were of value as ventilating shafts for the sewers. It was stated, in reply to Mr. Councillor Hampson, that three of these posts were connected with the sewer. Mr. Councillor Heap pointed out that these old lamps cost the town between £800 and £900 per annum to maintain. Mr. Alderman Cocker said it was even worth £900 or £1,000 per year to have these large lights between the two northern piers. Mr. Councillor Pearson said Mr. Councillor Hampson surely knew that a complete scheme had been got out for the lighting of the streets running off the Promenade. The old lamps had been condemned by electricians, and it had been proved that the lamps consumed three times as much current in proportion to the light they gave. It was an exceedingly expensive and obsolete system, and there was no necessity for the ugly posts to remain up any longer. The amendment was not carried. Mr. Councillor Hampson then proposed a further amendment that the iron posts remain standing. Mr. Alderman Bickerstaffe seconded, and, after further discussion, a vote was again taken, 10 voting for the amendment and nine against. The iron posts will therefore remain in their present position.

Lighting at Manchester.—As mentioned in previous issues, the Manchester Corporation, on the advice of Dr. J. Hopkinson, have had erected a central station on the five-wire system. The station is situated in Dickenson street, and for the portion of the scheme now in operation six engines of 90 h.p. and four of 250 h.p. have been built. Six large Lancashire boilers provide the steam power. A dynamo is connected to each engine. The conduits are composed of concrete and flagged at the top. In places where the traffic is heavy—at street crossings, for instance—iron pipes take the place of the conduit, and here the cables bearing the current are solidly protected. In the conduits themselves the only protection necessary is air insulation. In considering the question of cost, remarks a Manchester paper, we are soon in the region of comparison. Our commercial instincts naturally lead us to enquire whether the new illuminant is as cheap as the old, and those in search of information on this point will learn that the Corporation has two sets of charges. On one scale the charge is 8d. a unit; on the other a fixed charge is made for the plant, and in addition 2d. a unit. The consumer may make his choice, and in doing so will be determined by the nature of the supply that he requires. Once provided with a supply, he will probably find that if he should use it to a very limited extent electricity will be dearer than gas. On the other hand, he will find that if he should make use of electricity during 960 hours in the course of a year on the fixed charge, and 2d. a unit scale, the expense, observes the same paper, will be about the same as if he burned gas at a cost of 2s. 6d. per 1,000ft. during a similar period. Burnt for 960 hours during a year on the scale mentioned, electricity will cost 5d. a unit, and at this rate it is about the same price as gas. The people of Manchester have shown their appreciation of the benefits of the new supply in an unmistakable manner. Already the resources of the Dickinson street works, and the plant at present in use, are being tested to the full extent. So far the area of supply is confined to the centre of the city, but the requirements of the people outside these limits will be met as they are made known. The consulting engineer, Dr. Hopkinson, had as his local representative Mr. Charles Hopkinson, M.I.C.E., Princess street, Manchester, who attended to the practical work of superintending the construction of the work and the laying down of the plant. Mr. Wooler is the electrical engineer in charge.

Lighting of the City.—At the meeting of the Commission of Sewers last week, as referred to in our previous issue, a statement was made by one of the speakers concerning the cost of lighting the streets with electricity and with gas. The difference was very wide, and in order to obtain some further information upon it a representative of the *City Press* has since called at the offices of the City of London Electric Lighting Company, Great Winchester-street, where he had a conversation with one of the officials. The following is the substance of it: "You ask the difference in cost," said the official referred to, in response to an opening remark. "The simple answer is that you get so much more light than under the old system. It is value for money expended. There have been replaced by electricity 1,219 gas lamps of 16 c.p. each, totalling up to 20,000 candles. The arc lamps now in position are 478 in number, out of 515 provided for in the contract with the Commission of Sewers. These lamps give a light of 1,000 candles each, making in the aggregate 478,000 candles, or, say, 23 times as much light as with gas. The company are still waiting for the order from the Commission to proceed with the lighting of the side streets, and also for positions to be assigned to 33 arc lamps, which, with four now in course of erection, will complete the total of 515 already named." "But this increase of cost over the old system of lighting—has it come as a surprise—is it a new revelation? I mean, of course, to those who should be in a position to know officially?" "Not at all. It was well known what the cost would be according to the contract, which was entered into in May, 1890. The charge was fixed at £26 per year for arc lamps, £10 per year for incandescent lamps of 200 watts, and £5 for lamps of 100 watts." "Then you think there is no reason for complaint as to cost, and none for surprise at the increase?" "As already stated, there has been no change made in the contract, and the figures given show what an enormous difference there is in the amount of light supplied." "Leaving the streets now, are orders for private lighting coming in well?" "Yes; already the company are supplying about 40,000 incandescent lamps, and in a week or two this number will be very largely increased." "Complaints are heard every now and then that private consumers cannot get 'joined on' to your system." "Quite so. People see the lamps outside their doors, and wonder why the light cannot be brought into their houses at once. But the street lamps are run on a different system from the private, and the light cannot be put on the public lighting circuit. Depend upon it, the company are most anxious to push on the private light-

ing as much as possible. It is to their interest to do. It means increased revenue. There is one matter that I should like you to make a note of, if you will. It is that of 'failures' of lamps The report upon these gave a total of 302 lamps as having failed in six months, which, of course, appears a very large number But many of these failures were but for a moment or so, perhaps Put into lamp hours the thing wears quite a different aspect Thus there were 787,245 hours, and the failures amounted to only 370 hours."

Cambridge.—The Electric Lighting Committee of the Town Council reported at a meeting of the latter last week that they had received the following letter from the manager of the Cambridge Electric Supply Company, Limited: "By the regulations made by the Board of Trade, under the provisions of the Electric Lighting Acts, and of the Cambridge Electric Lighting Order, 1890, it is provided that the supply of energy by the company shall, except so far as may be otherwise agreed on from time to time between the local authority and the company, be constantly maintained. My directors find from the experience gained up to the present time, that the maintenance of a constant supply throughout the year results in considerable pecuniary loss to the company, without any corresponding benefit to the public. They, therefore, desire to come to an agreement with the Corporation that for the present there shall be the following exceptions to the delivery of a constant supply viz., on weekdays during the period between October 1 and June 25 from 2 a.m. to 6 a.m., and during the period from June 26 to September 30th from 1 a.m. to 5 p.m. On Sundays during the period between 1st October and 25th June from 9 a.m. to 5 p.m., and from 1 a.m. to 6 a.m., and during the period from June 26th to September 30th from 1 a.m. to 6 p.m. As soon as the consumption of current warrants the delivery of a constant supply without exceptions, it will be the pleasure as well as to the interest of my directors that this shall be effectively maintained I shall be obliged by your bringing the matter before the Electric Lighting Committee as early as possible The chairman, a director, and myself would be glad to attend as deputation to the committee and lay the matter more fully before them." The committee recommended that from the present time until the 31st day of December, 1894, the company be permitted to make the following exceptions to a constant supply—viz., on weekdays from the 1st of October to the 25th of June inclusive, from 2 a.m. to 6 a.m. From the 26th of June to the 30th of September inclusive, from 2 a.m. to 5 p.m. On Sundays from the 1st of April to 30th of September inclusive, from 1 a.m. to 6 p.m. From the 1st of October to the 31st of March inclusive, from 1 a.m. to 4 p.m. But in no case on Sundays shall the supply be shut off after sunset. Alderman Kett, who proposed the adoption of this report, remarked that the engineer said that as soon as they got further demands from the public the company would only be too glad to have a continuous supply. The company asked that for a time only an intermittent supply should be dealt out Councillor Ginn, who seconded, said that the committee thought the company, being a new company, and the Corporation interested in its success, that they should meet them as far as they possibly could. Councillor Nichols was strongly opposed to the adoption of the report. He moved as an amendment that the Council proceed to the next business. Councillor W. F. Taylor seconded the amendment, which, on being put, was lost. Councillor H. M. Taylor then said they had no guarantee that some persons to whom the electric light was supplied would not be very much wronged if they passed the report of the committee. He thought the company ought to assure them that they had made application to their customers, and they ought to tell them how many of those customers were willing to consent to the alteration they proposed to make. He proposed as an amendment "that the consideration of the report of the Electric Lighting Committee be postponed until the next meeting." Councillor F. Morley seconded this amendment, which, on being put to the meeting, was carried. The Town Council subsequently decided, on the recommendation of the Guildhall and Building Committee, to instal the electric light in the rooms in the Guildhall occupied by the School of Art. An estimate for the work, amounting to £17, had been obtained from Messrs. Russell and Co., and this was accepted.

PROVISIONAL PATENTS, 1893.

NOVEMBER 6.

21007. **Improvements in electrical arc lamps.** Charles Edward Harold Edman and Joseph Green, 18, Southampton buildings, Chancery lane, London.

21046. **Improvements in electric switches** Arthur Moore Thompson and William Walter Gerald Webb, Holly Bank, Crewe.

NOVEMBER 7.

21094. **A method of improving electric light switches, bell-pushes, keyhole-plates, door numbers, name-plates, dials of clocks, house fittings, and the like, by the application of luminous paints thereto.** Herbert Furnell Laughton, 20, Warrington crescent, Maida Vale, London.

21117. **Improvements in and relating to electrical dynamometric governors.** Robert Willsher Weekes, 70, Market street, Manchester.

21192. ***Improvements in incandescent electric lamps.*** *Gilbert Scott Ram 32, Oakley-square,* London.

NOVEMBER 8.

21199. **Power transmission by alternate-current motors.** Wilfrid L. Spence, 9 Newark drive, Pollokshields, N.B.

21201. **A multiple circuit microphonic transmitter.** Frederick Thomas Trouton, Caerleon, Killiney, co. Dublin.

21270. **Improvements in and in constructing pianoforte cases for lighting music-desks by electricity.** James Alfred Murdoch, 53, Chancery-lane London.

NOVEMBER 9.

21324. **Improved electric cables, and method of and apparatus for manufacturing the same.** Sebastian Ziani de Ferranti, 6, Lord-street, Liverpool. (Complete specification.)

21327. **Improvements in electric meters.** Emanuel Bergmann and Carl Erben, 6, Lord street, Liverpool.

NOVEMBER 10.

21370. **Improvements in mouthpieces for telephone transmitters.** William Henderson Turcan and Robert Connell Morton, 87, St. Vincent street, Glasgow.

21379. **Improvements in the application of electric light for photographic purposes and apparatus therefor.** Andrew George Adamson, 154, St. Vincent-street, Glasgow.

21420. **Improvements in primary batteries.** William Heaton Longsdorf, 73 Cheapside, London. (Gardner Hewett, United States.)

21430. **Improvements relating to incandescent electric lamps.** Charles John Peach Robertson, 6, Bream's buildings, Chancery lane, London. (Complete specification.)

21434. **Improvements in electrically-heated ovens.** Friedrich Wilhelm Schindler, 433, Strand, London.

21435. **Contact device or circuit connection for electric heating bodies and analogous electrical appliances.** Friedrich Wilhelm Schindler, 433 Strand, London.

NOVEMBER 11.

21496. **Improvements in the working of railway points and signals by electricity** Illius Augustus Timmis, 2, Great George street, Westminster.

21529. **Improvements in electrolytic cells.** Ludwig Mond and Robert Ludwig Mond, 6, Lord street, Liverpool.

21551. **A device for the prevention of local action in electric batteries and improvements in connection therewith.** Harry Theodore Barnett, 14, Narcissus-road, West Hampstead, London.

SPECIFICATIONS PUBLISHED.

1890.

16613. **Incandescent lamps.** Mehrle. (Second edition.)

1892.

18700. **Electrical ceiling roses.** Poole and others.

20488. **Closing an electric circuit by the passage of a train over a line of railway** Webb and Thompson.

20789. **Transmitting sounds electrically.** Lorrain. (Chamond.)

21372 **Electric insulators.** Espeut.

23658. **Electrical cables, etc.** Edmunds.

1893.

6935. **Electrical meters.** Brookes. (Wirt.)

10535. **Electrical signalling and printing telegraph systems.** Johnson (M'Caskey.)

10843. **Electric railways and tramways.** Claret and Vuilleumier

15906. **Electrolytic apparatus.** Young (Société Outhenin Chalandre Fils et Cie).

16562. **Electric motors.** Willcox. (Esmond.)

17127. **Electrolytic cells.** Cranoy.

17658. **Electric current conveyers.** Barker. (Lawrence Electric Company)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	18
Electric Construction	—	1¾
House to House	5	2½
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¾
	3	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	7¾
National Telephone	5	4¼
St. James', Pref.	—	8
Swan United	3¾	3½
Westminster Electric	—	5¼

NOTES.

The Gale has played havoc with the telephone and telegraph wires.

Aluminium and Coal.—The price of aluminium is falling; so is that of coal.

Sunday Telephony.—The Cardiff telephone exchange is to be kept open on Sundays.

Nancy.—It is proposed to establish an aerial electric tramway between Nancy and Dombasle (Meurth and Moselle).

Central London Railway.—The London Central Railway Company will apply to Parliament next session for an extension of time.

Oban.—An industrial and fine arts exhibition has been opened. The halls are lighted by electricity by the Caledonian Electric Supply Company.

An Enterprising City.—There are 50 miles of electric railway and 1,600 telephones in use in Grand Rapids, Michigan—an enterprising city of 90,000 inhabitants.

Society of Arts.—A silver medal has been awarded to Mr. Gisbert Kapp for his paper read last session on "Some Economic Points in Connection with Electric Supply."

Measurements.—Lectures on industrial measurements are about to commence in Paris at the Laboratoire Central d'Electricité under the auspices of the Société Internationale des Electriciens.

Wakefield.—The Wakefield Corporation intend to apply to the Board of Trade for a provisional order authorising the supply and distribution of electricity for public and private purposes within the city.

Locomotion in London.—The London County Council have voted the sum of £500 for obtaining information on the subject of locomotion in London. The matter is referred to fully in another column.

Tasmania.—An international exhibition is to be held at Hobart in 1894-95. An influential London committee has been constituted, with offices at Tasmania Government Office, 5, Victoria-street, London, S.W.

Roubaix.—The Compagnie Nouvelle des Tramways Roubaix-Torcoing has obtained permission from the Municipal Council of Mouveaux (Nord) to construct an electric tramway on the overhead system.

Women's Voices.—It is stated that women's voices do not "carry" well on long-distance telephone lines. Their high notes do very well over short lines, but are not heard distinctly enough on the longer lines.

The Electro-Harmonic Society.—The "ladies' night" of this society will take place this evening in the Banquet-room of the St. James's Hall Restaurant, Regent-street, W., at eight o'clock. The programme was given in our last issue.

Society of Arts.—On Monday a lecture on the "Art of Book and Newspaper Illustration," by Mr. Henry Blackburn, will be given; and on Wednesday a paper will be read on the "Regulation of Street Advertising," by Mr. Richardson Evans.

Gas Again.—An accumulation of gas in one of the conduits of the Manchester municipal electric light undertaking led to an explosion last week, resulting in the upheaval of a manhole cover and the partial destruction of a portion of a main.

Treatment of Phthisis by Ozonised Air.—M. Hérard has analysed a note by MM. Labbé and Oudin regarding the treatment of phthisis by ozonised air obtained by electricity. M. Hérard concludes favourably on the application of this method.

Londonderry.—The report of Mr. Blake, electrical engineer to the Corporation, and which was recently presented, dealt with the progress made in the erection of generating stations, laying underground cables, lamp-pillar erections, and similar operations.

The Theatrophone.—Instruments of this kind have been introduced in Dover. Recently the Folkestone Theatre was connected up by a special wire, and some subscribers in Dover and other parts of Kent had the pleasure of listening to the performance of the musical burlesque "Little Godiva."

Science Master.—A science master having special knowledge of chemistry and physics is required for the Kingston-on-Thames Endowed Schools. The salary is £250 per annum, and particulars are obtainable from Mr. John Durham, clerk to the governors, Kingston-on-Thames Endowed Schools, Kingston-on-Thames.

The Blackpool Cars.—Delays in the working of the cars are reported to be constant. It is said that the plant which produces, or which should produce, the current is worked out. New engines and dynamos have, it is stated, been ordered to be in readiness for the time when the plant will be transferred to the electric light works.

Government and Telephony.—Mr. A. Morley, in reply to Captain Bagot, on the 17th inst., said that he could not state when the terms of the agreement between the Post Office and the National Telephone Company would be laid on the table of the House. There were still some points to be considered, but there should be no delay

Obituary.—M. Paul Jousselin, the president of th Société des Ingenieurs Civils de France, has just succumbed to an attack of pneumonia. Mr. James Brand, who died suddenly at Sanderstead Court, Surrey, on Tuesday, was largely interested in British telephone undertakings, and was formerly chairman of the National Telephone Company.

Serious Fire.—A large five-storey factory, used for the manufacture of electrical appliances and for supplying Halifax shops with electric light, was burned out yesterday morning. A gable fell out on to the residence of Mr. Emmott and demolished a great part of it. The damage will prove very heavy, and the electric lighting of about 50 shops has been cut off.

They Did not Like Welsh.—One day last week, according to rumour, a gentleman was using the telephone at an hotel in Wales and speaking in Welsh to a friend in another part of the town. Owing to a slight hitch, the conversation was not carried on as rapidly as could be wished. "Stay a moment," said the Hebe in attendance, "let me speak it in English. Perhaps the wires can't carry Welsh."

The International Maritime Congress.—The "Minutes of Proceedings" of the International Maritime Congress, held a few months ago in London, have now been issued by Messrs. Unwin Bros., of 27, Pilgrim-street, E.C. The fourth section, which dealt with lighthouses, buoys, fog-signals, etc., was reported in our columns at the time. The "Minutes of Proceedings" will form valuable works of reference.

Boiler Explosions.—The Scottish Boiler Insurance and Engine Inspection Company, Limited, of 38, Lloyd-street, Manchester, and of Glasgow, have published an illustrated pamphlet dealing with the various causes of boiler explosions. The company issue policies of insurance covering all loss or damage to boilers, buildings, and machinery arising from steam-boiler explosions or collapse

of flues, and also undertake the periodical inspection and indication of steam-engines.

Engineers and Shipbuilders.—The second general meeting of the North-East Coast Institution of Engineers and Shipbuilders will take place to-morrow, the 25th inst., at the Athenæum, Church-street, West Hartlepool. Mr. W. Hok's paper "On a Method of Comparing Steamship Performances and of Estimating Powers and Speeds of Ships" will be discussed, and a paper "On the Dangerous Working Heat of Mild Steel and the Effect of Annealing and Air Cooling," by Mr. Joseph Nodder, will be read.

Lighting in Paris.—A petition has been addressed to the Paris Municipal Council complaining that the Société Belge du Secteur des Champs Elysées do not conform to the regulations under which they work. It is said that a minimum of £20 is charged for making a connection by means of a small branch conductor, whereas the companies in the other Parisian districts only charge £4 for similar work, and often make the connection free, and that, among other matters, the supply of current is suspended from six to eight hours in the 24 hours.

Provisional Orders of the Board of Trade.—Under the title of "Provisional Orders of the Board of Trade," Mr. F. J. Crowther, parliamentary agent, has prepared a manual concerning the various steps necessary in the course of an application to the Board of Trade for provisional orders in the cases of gas and water, tramway, pier and harbour, and electric light undertakings. The manual, which is published by Messrs. Jordan and Sons, of 120, Chancery-lane, W.C., is intended not only for the use of promoters of such orders, but also for their opponents.

The "Medical Battery" Company.—The hearing was resumed on Wednesday at the Marlborough street Police Court of the charges of conspiracy to defraud against Mr. C. B. Harness, the managing director of the Medical Battery Company, Limited; Mr. J. M. M'Cully, physician; Mr. C. B. Hollier, salesman; and Mr. Dudley Towers, *alias* William Robert Sellman, a masseur. Further evidence was given, and the case was again adjourned for a week. Mr. Justice Vaughan Williams, in the Chancery Division of the High Court of Justice, on the same day made a compulsory winding-up order in the case of the "Medical Battery" Company, Limited.

Lighting at Brussels.—The central station was set in operation at the commencement of the present month. The station, which has been constructed and equipped by the India Rubber, Gutta Percha, and Telegraph Company, Limited, of Silvertown, is laid out for the supply of 20,000 16-c.p. lamps. There are at present installed two 500-h p. steam-engines and two dynamos, together with a battery of accumulators capable of serving 5,000 lamps. Additions will be made as required. The current is sent out on the low-pressure system from sub-stations served by feeders. The plant will be in operation from sunset till midnight, after which current will be furnished by the accumulators.

Exhibition at Santiago.—The Department of Science and Art has received through the Foreign Office a despatch from her Majesty's Minister in Chile calling attention to an exhibition which it is proposed to hold next year at Santiago, dealing with mining and metallurgy. The exhibition will be opened in the second fortnight of April, 1894, but the exact date is not yet known. The eight sections of the exhibition will comprise electricity, mining machinery, mechanical preparation of minerals, metallurgy, chemical industries, statistics and plans, and mining and metallurgy products respectively. Applications for space may be made to the Chilian Legation in London.

Artificial Rain.—M. A. Baudouin has presented to the Academie des Sciences a note referring to experiments made to obtain rain by drawing electricity from the clouds by means of a kite. One experiment took place on the 15th October, at about 5.15 p.m. The author then obtained contact with the clouds situated at an estimated distance of 1,300 yards. At that moment a local cloud was noticed, and then several drops of rain fell. As soon as the contact ceased, which was effected by hauling down the kite, the normal state of affairs was resumed at 5.30 p.m. M. Baudouin adds that as far back as 1876 he obtained rain in the same manner on several occasions on the plains of El Meridj, in Tunis.

The Royal Society.—The Royal Society's medals this year have been awarded as follows: The Copley Medal to Sir George Stokes, F.R.S., for researches and discoveries in physical science; a Royal Medal to Prof. Arthur Schuster, F.R.S., for spectroscopic researches and investigations into terrestrial magnetism and disruptive discharge through gases; a second Royal Medal to Prof. H. Marshall Ward for researches into the life history of fungi and schizomycetes; and the Davy Medal to Messrs. J. H. Van 't Hoff and J. A. Le Bel for work in connection with the theory of asymmetric carbon and its bearing on the constitution of optically active carbon compounds. The distribution of the medals will take place at the customary meeting on St. Andrew's Day (30th inst.).

Speed of Propagation of Electricity in a Wire.—M. Blondlot has described some experiments which he undertook to determine the rapidity of propagation of an electric disturbance along a copper wire by means of a method independent of theory; and he gives as follows the results obtained with lines of unequal length: (1) The equality of the values of the speeds obtained (183½ *miles* and 184¾ miles per second) with two lines of different lengths (1,115 yards and 1,973 yards) shows that the propagation movement is tolerably uniform; (2) these figures are perfectly in accordance with those he had previously obtained by another method; (3) the experiments undertaken have the principal advantage of being independent not only from theory, but also even of the existence of electromagnetic oscillations and undulations.

The Phonopore.—The phonopore telegraph, which is in use on several of our railways, and which enables an extra independent message to be sent on the ordinary telegraph wire in either direction at the same time that telegrams are being sent by the ordinary telegraph, has made, we are informed, an additional claim to usefulness by the fact that communication has been maintained by its means under circumstances which rendered the ordinary telegraph altogether useless. The Phonopore Company states that it has recently happened, on four different lines, that though the ordinary telegraph could not work on account of a breakage of the wire, the messages were sent by the phonopore just as if nothing unusual had taken place on the wire. The current by which the phonopore is worked jumped the gap of the breakage, and thus kept up the communication whilst the ordinary telegraph was silent.

Lighting at Edinburgh.—When the members of the Town Council met on Tuesday, Councillor Mortimer moved the disapproval of the minutes of a recent meeting at which it was resolved to light certain portions of the city by electricity. This motion was seconded, but Lord Provost Russell urged the adoption of the minutes, being seconded by Councillor Walker. Councillor Mackenzie, a member of the Electric Lighting Committee, submitted statistics showing the difference in cost between lighting by

gas and electric lighting in the various streets comprised in the proposed area. There would be displaced by the electric light, if it was carried out, 782 gas burners, which cost £1,310. If they deducted from that the office expenses, which represented £68, being 1s. 10d. per burner, the total saving in cost would be £1,242, while 148 or 150 arc lamps would cost £2,960, making an additional cost of £1,718. But there was a patent which was being applied to arc lamps, and which would, Prof. Kennedy said, permit them to turn off the light half-way, and that would save, perhaps, from £600 to £700 per annum. Some further discussion ensued, and the minutes were adopted.

Dangers of Coal Gas.—With reference to the note given in another column concerning an explosion at Manchester, an electrical contractor writes as follows to a provincial contemporary, which published the statement in sensational terms: "As this paragraph is likely to mislead your non-technical readers, and consequently damage us contractors, may I be permitted to make a few observations regarding the paragraph referred to? In all large towns, such as Manchester, there is a considerable leakage of both sewer and coal gas. These gases find their way into the pipes and culverts of the electric system, and once there, and mixed with the proper proportion of air, form a highly explosive mixture. The slightest spark between the electric cables then explodes the mixture. To blame electricity is hardly fair. Why not head the paragraph 'Dangers of Coal or Sewer Gas'? If a miner's safety lamp ignites an accumulation of fire-damp in a coal-pit, would anyone call it the 'Dangers of Using Safety Lamps'? I think not. There is no mention of gas in the paragraph. My reason for troubling you with this letter is that the paragraph is likely to do us contractors a good deal of harm by frightening our probable customers." We fully agree with the contractor's remarks.

Liquid Air.—In connection with the forthcoming lectures at the Royal Institution on "Air, Gaseous and Liquid," it may be mentioned that Prof. Dewar has successfully conveyed a considerable quantity of liquid air from London to Cambridge. The liquid air was carried in a double glass flask, the space between the inner and outer flask containing nothing but extremely attenuated mercurial vapour, together with a little liquid mercury. On pouring liquid air into the inner flask, its outer surface is rapidly covered with a mercurial film of extreme thinness, forming a reflecting surface highly impervious to radiant heat. As soon as this is formed, the whole apparatus is packed in solid carbonic acid, which at once freezes the liquid mercury, arrests the deposit upon the mirror, reduces the mercurial vapour to an infinitesimal quantity, forms an almost perfect vacuum, and supplies an envelope 80deg. below zero. Thus protected, the liquid air reached Cambridge with only a trifling loss of bulk, notwithstanding the incessant jolting of the railway. The protective power of the high vacuum and the mercurial mirror will be better appreciated if it be borne in mind that the difference of temperature between liquid air and solid carbonic acid is the same as between ice and boiling water.

The Subsidisation of the French Cable.—"It is not often," remarks the *Pall Mall Gazette* in yesterday's issue, "that questions of what may be called 'foreign policy' disturb the peace of the Australian Governments. Lately, however, they have been paying a considerable amount of attention to extra-colonial matters. First, as we have already noted, there has been a good deal of embittered controversy over the action of the New South Wales and Queensland Governments in subsidising the French cable from Australia to New Caledonia, constructed avowedly as the first link in a chain of communication which is to be extended to Canada under the same auspices. Lord Ripon has taken an unusually Imperial view of the matter, and has made no bones of expressing his concurrence with the protest which emanated from the Victorian Premier on the subject. When the mail just to hand left, hot controversy was raging over the publication in the Melbourne press, of Lord Ripon's despatch communicating the views of Mr. Gladstone's administration on the unpatriotic action of the two Eastern colonies in subsidising the further intrusion of France into a sphere which only a little time back they were frantically proclaiming to be the sole domain of the Australian branch of the British Empire."

Artificial Diamonds.—Reference was already made to this subject a little time ago in connection with the experiments of M. Moissan. To obtain the powerful pressure which he judged requisite to the formation of the diamond, M. Moissan conceived the idea of utilising the property that certain bodies possess of increasing their volume when cooling from a liquid to a solid state. He placed silver and charcoal of sugar in an electric furnace and fused the metal to a state of ebullition; a certain quantity of carbon was thus absorbed by the metal. The mass was then thrown into water, and at once formed a shell of solid silver. When this was withdrawn from the water and allowed to cool slowly, the pressure of the kernel of molten silver contained in the exterior shell, which expanded in the process of cooling, precipitated the carbon in the form of microscopic black diamonds. Following this experiment, M. Moissan enclosed in a cylinder of soft iron a certain quantity of charcoal of sugar, and plunged it into a bath of liquid iron, placed in an electric furnace. Withdrawing the crucible from the furnace, he plunged it in water and allowed the mass, as soon as the exterior shell was formed, to cool gradually. The result was the production of genuine diamonds, microscopic indeed, but still true diamonds.

Electricity Applied to Domestic Purposes.—A lecture on "Electricity as Applied to Domestic Purposes" was recently delivered at Westwood House, West-hill, Upper Sydenham, by Mr. G. Offor, M.I.E.E., managing director of the Crystal Palace District Electric Supply Company, Limited. The lecture has now been printed in the form of a pamphlet, a copy of which has been forwarded to us by the author. In dealing with the district covered by the company's parliamentary powers, Mr. Offor pointed out that the area lay in the counties of Kent and Surrey, in the parishes of Lambeth and Camberwell, in the districts of Lewisham and Beckenham Board of Works, the borough of Croydon, and to a large extent in the county of London. He did not think the company would ever come under the compulsory sale powers of the Act of Parliament, as it would involve a combination of the local authorities of the districts mentioned to deal with the matter, which he regarded as practically impossible. The lecturer briefly referred to the system of supply adopted by the company, and mentioned cases, on the one hand, where the electric light had proved to be cheaper than gas lighting, and, on the other, where the cost had been about the same as illumination by gas. He next referred to and exhibited electric kettles, frying and stew pans, grills, flatirons, cigar-lighters, small electromotors, and concluded by giving particulars of dividend-paying electric light companies, and of the number of lamps supplied from their respective stations.

Electrical Conductivity and Specific Resistance of Metals.—The experiments of Profs. Dewar and Fleming on the electrical conductivity and specific resistance of metals at extremely low temperatures have been continued

since the publication of the initial paper last year, and further results have recently appeared in the *Philosophical Magazine*. The object of these further experiments was to determine the specific electrical resistance of metals and alloys over a wide range of temperature, from about 200deg. C. to nearly – 200deg. C., the temperature of liquid oxygen. A large number of pure metals were subjected to test, including gold, silver, platinum, copper, aluminium, iron, tin, nickel, zinc, cadmium, lead, magnesium, palladium, and thallium. From the tables published it appears that the order of conductivity of these metals is very different at low temperature to what it is in the higher ranges. At the lowest temperature, reached by means of liquid oxygen and a vacuum as well, copper is the best conductor, instead of silver, and there seems to be a real or fortuitous connection between the sonorous properties of the metals and their conductivity. Thus gold, silver, aluminium, and copper are all good conductors, while lead, zinc, tin, palladium, and thallium are inferior. The experiments tend to confirm the theory on which they were originally based—viz., that at absolutely zero temperature the specific resistance of pure metals would become nil, and that most unattainable of rareties, a perfect conductor, would be actually realised. The observations are to be continued into even lower temperatures in a further course of experiments.

Influence of a Three-Wire System on Telephone Wires.—In a paper given in the *Elektrotechnische Zeitschrift* of the 17th inst., M. Th. Erhard, of Altona, deals with the influence upon telegraph and telephone wires of a three-wire system of distribution. The author states that as far as disturbances caused in telegraph wires through strong current installations is concerned, the post and telegraph authorities admit that such interruptions are accounted for by extraordinary events, and that therefore they are almost left out of consideration. The case is similar with disturbances in the working of telephone lines in so far as understanding by means of the telephone is concerned. The author enters into details regarding various interruptions at Altona. He concludes that in regard to the falling down of indicator switches in the telephone exchanges, the bare middle wire rather brings about fewer disturbances in telephone working than the insulated wire; but when the worst enemy of telephone wires, the constant passage of current by which it is impossible to replace the indicator switches, is considered, the advantages of the bare middle conductor over the insulated central wire considerably preponderate. As to disturbances in telephone working through the impossibility of making connections with subscribers, the bare copper conductor is not more disadvantageous than the one that is insulated. The interruptions in telephone circuits caused by strong currents are principally insignificant in relation to the other disturbances occurring in telephone working. The observations hitherto made have in no single case led to the apprehension of greater disturbances in telephone circuits, and Mr. Erhard therefore believes that by mutual goodwill conductors carrying both strong and feeble currents can be placed near one another without troubling about either a bare or insulated central conductor. One of the great advantages of the bare middle conductor is that the insulation of house installations can be better maintained than with an insulated middle wire, and greater security in telephone working can thereby be obtained. Recent insulation measurements in house installations of from one to two years' standing showed insulation resistances of not less than 100,000 ohms.

Extensions at the Bradford Station.—The extensions which have been in course of being made for some months past at the central station of the Corporation are now approaching completion, and the output of the works will shortly be increased to the extent of 30 per cent. The alterations have been carried out under the supervision of Mr. Shoolbred, the engineer retained by the Gas and Electricity Supply Committee. The station is situated near the bottom of Bolton-road, with a frontage to that thoroughfare, and overlooking at the back the Jollity Theatre and Canal-road. The length of the frontage is 165ft., and the width of the plot of ground is upwards of 70ft. Of the side nearest Canal-road, a length of 105ft. is occupied by the engine-house, a single-storeyed building 22ft. wide, with a lodge opening towards Canal-road at each end. Side-by-side with the engine-house is a building precisely similar in construction and dimensions. From the middle of this building rises a tall chimney, with the boiler-house at the further end of the building and the storage-battery room at the town end. The alterations include the erection of a building 165ft. in length, 22ft. in width, and two storeys in height along the whole frontage to Bolton-road. The basement or first storey is used, so far as the ends are concerned, for the storage of coal, and fuel can be shot direct from Bolton-road. The intermediate space has been utilised for the laying down of boilers and the erection of a smoke economiser. When the Gas and Electricity Supply Committee deem it advisable to spend more money on what has thus far proved a most profitable investment, the works will be further extended by raising the engine-house and the intermediate building to the height of the newly-erected one. The cost of the new building will be from £6,000 to £7,000. The principal additions to the plant consist of two Willans engines, each of 200 i.h.p. There were previously seven engines, with a total of 1,200 i.h.p., and the existing engine-house will provide space for two new engines of the size of the latest additions. There are four Lancashire boilers on the premises, each 20ft. in length by 7ft. in diameter, and one of the Babcock and Wilcox type. The storage-battery room has proved of great utility, as it provides the supply of electricity for 10 hours out of the 24.

Rapid Transit.—In the course of an article in a recent issue of the *St. James's Gazette*, a correspondent says: "Travelling by train at 150 miles an hour is by no means slow work, but there are certain electrical engineers on the Continent who say that such a speed is quite possible. They have gone further than this. So sanguine are they of the truth of their assertion that they have accepted a contract to build electric motors which shall run at this speed on a line to be laid between Brussels and Berlin. It seems at first sight a rather big jump from 60 or 70 miles an hour—the highest speed that has been hitherto practicable on the best of modern railroads—to a speed of more than double that velocity. But to the electrician most things are possible—at all events, on paper. Indeed, electrical engineers have long been aware that if once they can overcome one or two little difficulties in the system, they will be able to produce electromotors of a speed that will make even the Brussels-Berlin scheme seem very slow travelling. The promoters of the new line on the Continent say they have found out the way, but whether they will succeed or not it is impossible to say until a trial has been made. If a storage battery of very light construction be someday discovered, high speeds may yet be possible by this system, and that is all that can be said on the matter. The engineers of the Brussels to Berlin railway have wisely owned their inability to cope with the difficulties of weight, which are the chief drawbacks to the storage system. Their idea is to feed the motors with current as they speed along the line. This can be done by using one or both of the rails as conductors for the current. There must be a

central generating station situated at least at every 10 miles along the route, where electricity is produced and supplied to the rails. The moment the current enters the latter it is practically available at any point, for the time occupied in travelling their length is inappreciable. It it be inconvenient to use the rails as conductors, the current can be collected equally well from an independent metal bar fixed all the way between the lines, as is done in the case of the South London Electric Railway. Although there is little or no limit to the distance electricity can travel along a conductor, its strength very soon begins to diminish; and unless the strength can be maintained uniformly the motor will not give satisfaction. Again, where the current is conveyed by rails there will always be a leakage to 'earth'; and this will happen no matter how carefully the rails may be insulated. In wet weather these leakages would render the railway practically unusable, for damp is an excellent conductor. If it were possible to keep the pressure uniform all the way and to avoid any leakage whatever, then 150—or, for the matter of that, 500—miles an hour would be perfectly practicable."

Hedgehog Transformers and Condensers.—In a paper read before the American Institute of Electrical Engineers, Messrs. F. Bedell, K. B. Miller, and G. F Wagner dealt with this subject. The first part of the paper formed a description of apparatus and measurement. The method of instantaneous contact was employed for obtaining the E.M.F. at various points of the phase, for which purpose the contact employed consisted of a needle attached to a revolving disc which cut through a fine stream of water at every revolution, and the potential difference was obtained by means of a multicellular voltmeter with a pneumatic damping arrangement, devised by Prof. Ryan. The Hedgehog transformer primary consisted of 1,426 turns of wire 0·072in. in diameter, arranged in 12 layers. Its resistance was 2·748 ohms, and its weight 29lb. The secondary consisted of 73 turns of cable composed of 19 strand of 0 058in. wire, with a resistance of ·0149 ohm, and weighing 12 5lb. The transformer was designed for 1,000 volts at 130 periods. Experiments show that at no load the lag of the primary current behind the primary E.M.F. is almost 90deg., which is greatly in excess of the lag shown by similar experiments upon transformers with closed magnetic circuits. The secondary E.M.F. at no load is almost opposite in phase to the primary E.M.F.—that is, almost 180deg behind it. With increased load the lag increased slightly, due to increased leakage. The curve for efficiency rises very rapidly as the load increases, reaching 90deg. at about one-eighth of full load. From quarter load it is nearly constant, rising to 96 6 per cent. at two-thirds load. It remains practically constant until full load is reached, and then falls off slightly on verload. The all day efficiency calculated on a basis of five hours at full load out of 24 hours is 91 8 per cent. There is a fall of about 2 5 volts in the secondary between no load and full load. Tests were then made with Stanley condensers in circuit and readings taken for determining the primary E.M.F., secondary E.M.F., primary and line current. The results of three runs are given in the following table, showing clearly the effect of the condenser in diminishing the line current, especially at no load:

Lamps in secondary.	Primary current.	Line current.
0	95	·187
15	1·24	867
45	3·07	2·73

At no load the line current is seen to be less than one-fifth of the primary current, or the value it would have if the condensers were absent; even under full load the reduction is considerable. As the results of these tests, the authors conclude the transformer upon which the investigation was made possesses two valuable features—high efficiency and good regulation. The experiments with the condensers demonstrate the practicability of their use to diminish the line current in transformer circuits, and points to their more extended use, as their manufacture is perfected and cheapened, not only in this, but also in other systems of alternating-current distribution

Electric Shot-Firing in Coal Mines.—A paper on this subject was read at Wigan recently by Mr. Peter Houghton before the Lancashire Association of Colliery Under Managers. The author said that he did not intend to treat the subject from a scientific point of view, but more from a practical one. He remarked that amongst the number of modern improvements in our mines it was found, owing no doubt to the large number of lives that had been lost by explosions and the introduction of the high-safety explosives, the question of electric shot-firing had made very rapid strides, and was now being pushed forward by her Majesty's inspectors of coal mines as the only safe method by which the safety explosives now in use could be fired. They all knew that Mr. Henry Hall, of their own district, strongly advocated the use of safety explosives fired by electricity in preference to gunpowder. The firing of a charge of explosive through the agency of a slow-burning fuse, though still very extensively practised in mining, presented such decided disadvantages in regard of uncertainty, and in some cases of danger, when compared with the firing by electricity, that it was not surprising to find what rapid strides the question of electric firing had made. The object of electrical firing was one of safety, though the mining fuse patented by Bickford effected an enormous improvement in the firing of charges in mines; yet there was little doubt that accidents in mining would be considerably reduced in number if electrical blasting were more frequently employed, especially in dangerous mines, instead of the uncertain system of firing by slow-burning fuse. Many men had met their doom through going up to a shot in the false belief that the fuse had burned out or become extinguished. In some instances the fuse had been burning for hours; also, explosive mixtures had been ignited and proved fatal to life, owing to the spit of the fuse when touched with the heated wire. With electric lighting the simplest precautions sufficed to ensure absolute safety, and in no case where it was necessary that safety explosives had to be used ought they to be fired by any other agency than electricity, because it was not wisdom to adopt a safe explosive and use for its ignition an unsafe means, thereby destroying, to a certain extent, its safety as an explosive. Perhaps, in no other district in this country had the use of the safety explosives and the firing by electricity become more general than in that district. The author went on to describe high and low tension exploders, and the methods of firing the detonators. He submitted that they ought to make themselves thoroughly acquainted with all things introduced for the safe working of mines. He contended that, owing to electric firing having been placed in the hands of persons not previously having had any knowledge of either the explosive detonators or the electric appliances for firing purposes, accidents had happened, not altogether through carelessness, but more from ignorance of those things which had fallen in their hands to use. But as knowledge was gained of what a detonator consisted of, and its danger when tampered with, so would men become more cautious when a miss-fire happened to regain the detonator, and he believed accidents from this cause would be few and far between. The author concluded by considering more fully the causes of miss-fires from electric firing.

WILLIAM GEIPEL.

Wm. Geipel, M.I.E.E., was born in 1860, and educated at Bristol Grammar School and at the College of Physical Science, Newcastle-on-Tyne. He passed the Oxford local examination in 1876, and the City Guilds examination in electric lighting and engineering in 1882, in both of which he obtained first-class honours. Mr. Geipel served a four years' apprenticeship in the workshops and drawing offices as a mechanical engineer, at the well known marine engine works of Messrs. T. Richardson and Sons, of Hartlepool, and was also six months at Hebburn Collieries, county Durham, studying mining engineering. He entered the service of the Anglo-American Brush Corporation in 1882. Shortly afterwards he was appointed assistant manager at their dynamo works in Borough-road. In 1884 he was sent by them to Edinburgh to superintend the lighting of the Forestry Exhibition, which was exclusively carried out by the corporation under his supervision to the entire satisfaction of the committee. Subsequently, Mr. Geipel negotiated and carried out for the Brush Company a large number of electric light installations in England and Scotland, and opened branch offices in Edinburgh and Glasgow, which were under his charge, as the company's superintendent for Scotland, up to 1889. Upon the formation of the Scottish Electric Supply Company, Mr. Geipel became one of the directors. In 1889, owing to the rapid development of their business, the Brush Company selected Mr. Geipel as their central-station engineer, in which capacity he controls the designing, working, and equipment of the Brush Company's central stations. For two years previous to his leaving Edinburgh he held an appointment at the new Heriot-Watt College as lecturer in electric engineering. Mr. Geipel is an occasional contributor to the technical Press and to the *Transactions* of the engineering societies.

INSTITUTION OF ELECTRICAL ENGINEERS.

The Institution of Electrical Engineers held their fifth annual dinner on Wednesday night at the Freemasons' Tavern, when a company of upwards of 170 gentlemen sat down under the presidency of Mr. W. H. Preece. The following were present:

Adams, Mr.
Albright, Mr.
Allen, Mr. A. W.
Anderson, Mr.
Anderson, Dr. W.
Andron, Mr.
Armstrong, Mr.
Armstrong, Dr.
Atherton, Mr.
Ayrton, Prof.
Bailey, Mr.
Banker, Mr.
Bar, Mr
Barry, Mr.
Beaumont, Mr. W. W.
Beevor, Mr.
Benedict, Mr.
Bennett, Mr.
Biggs, Mr. C. H. W.
Binswanger, Mr. M.
Binswanger, Mr. G.
Blackwell, Mr.
Bloomfield, Sir T.
Bramwell, Sir F.
Brett, Mr.
Brittle, Mr.
Browne, Sir J. C.
Brookman, Mr.
Buckney, Mr.
Budd, Mr.
Butcher, Mr
Chamen, Mr. C.
Chamen, Mr. W. A.
Chauvin, Mr.
Christie, Mr.
Clark, Mr.
Clark, Mr. L.
Creak, Captain
Cree, Mr.
Crompton, Mr.
Crookes, Prof.
Curra, Mr.
D'Alton, Mr.
Dieselhorst, Mr.
Dillon, Hon. C.
Dowson, Mr.
Duthy, Mr.
East, Sir G. C.
Easton, Mr.
Edgcome, Mr.
Edmunds, Mr.
Edwards, Mr.
Ehrhardt, Mr.
Elphinstone, Mr.
Ellis, Mr. Alderman
Epstein, Mr.
Erskine, Mr.
Esson, Mr.
Estler, Mr.
Evans, Mr.
Fairfax, Mr.
Ferranti, Mr.
Ffinch, Mr.
Fleetwood, Mr.
Forbes, Prof.
Forde, Mr.
Forster, Prof. G. C.
Fyers, Mr.
Garcke, Mr.
Gavey, Mr.
Gorham, Mr.
Grove, Mr.
Hammond, Mr. R.
Hammond, Mr. C. P.
Harris, Mr.
Harrison, Mr.
Hatt, Mr
Hawkins, Mr.
Heaphy, Mr.
Heaviside, Mr. A.
Heaviside, Mr. B.
Hedges, Mr.
Hill, Mr. L.
Hirst, Mr.
Holden, Major
Hookey, Mr.
Hooper, Mr.
Hopwood, Mr.
Hughes, Prof.
Hughes, Mr.
Hume, Mr.
Ince, Mr. J. O.
Ince, Mr. F.
Jackson, Mr.
Jenkin, Mr.
Joyce, Mr.
Kapp, Mr.
Keith, Mr.
Kempe, Mr.
King, Mr.
Kolle, Mr.
Lamb, Mr.
Lennard, Mr.
Lloyd, Mr.
Macrory, Mr.
Madgen, Mr.
Mance, Sir H.
Mavor, Mr.
Mayes, Mr.
Mordey, Mr.
Morley, Right Hon. A.
Mitchell, Mr. H.
Mitchell, Mr. P.
Mundella, Right Hon. A. J.
O'Brien, Mr.
Owen, Mr. Cunliffe
Perry, Prof.
Phillips, Mr.
Preece, Mr. A. H.
Preece, Mr. W. L.
Preece, Mr. W. H. (chairman)
Pritchett, Mr.
Pritchett, Mr. G. E. B.
Rawlings, Mr. W. R.
Rawlings, Mr. J.
Rawlinson, Sir R.
Reeves, Mr.
Reid, Mr.
Reynolds, Mr.
Richards, Mr.
Roberts, Mr.
Robinson, Mr.
Rorke, Mr. E.
Rorke, Mr. T.
Rücker, Prof.
Salomons, Sir D.
Sankey, Captain
Scholey, Mr. H.
Scott, Mr.
Sharp, Mr.
Shoolbred, Mr.
Siemens, Mr.
Smith, Mr. F.
Smith, Mr. W. O.
Smith, Mr. W. S.
Smyth, Mr.
Spagnoletti, Mr. C. E.
Spagnoletti, Mr. J. E.
Sparks, Mr.
Spiers, Mr.
Stewart, Mr.
Stuffe, Captain
Stothert, Mr.
Strange, Mr.
Straube, Mr.
Stroh, Mr.
Swinburne, Mr.
Swinton, Mr.
Thompson, Mr.
Trotter, Mr.
Tunzelmann, Mr. de
Turner, Mr.
Unwin, Prof.
Vose, Mr.
Walker, Mr.
Wallace, Mr.
Wallis Jones, Mr.
Ward, Mr. G. G.
Ward, Mr. J.
Ward, Mr. N.
Ward, Mr. A. F.
Webb, Mr.
Webber, General
Wells, Colonel
Wharton, Captain
Wilks, Mr.
Willett, Lieut.
Wilmot, Mr.
Wilson, Mr.
Winter, Mr.
Wright, Mr.
Wright, Mr. A.

The PRESIDENT, after dinner, and after the toast of "The Queen" had been honoured, proposed "The Learned Societies."

Sir J. CRICHTON BROWNE, responding, said the learned societies were all standing tip-toe, eager to see what electrical engineers were going to do next. They were full of gratitude and admiration for the splendid achievements of electrical engineers in recent years, and they had a lively sense of favours to come. They had festooned our homes with beautified glow-worms; they had stretched our ears, not in any asinine sense, so that they extended all over the town, and even as far as Paris; they had kept us in hourly and sympathetic vibration with everything that was going on in the uttermost quarters of the world; they whirled us about; they elevated them and depressed them; they welded our metals like the gnomes; they performed chemical transmutations like the alchemists; and they even treated us when we were ill, like the Royal College of Physicians. They had vastly increased the comforts and convenience of modern life; they had added enormously to the means of human intercourse; they had afforded invaluable assistance to the students and investigators in every department of science. To find a parallel to their splendid achievements of recent years and to the expectations they had created, it would be necessary to go back to the sixteenth century, when Columbus and his followers, by their discoveries in the

New World, created great hope and expectation; and he was certain that when the history of Queen Victoria's reign came to be written there would be no more brilliant chapter in that history than the one which recorded the exploits of electrical science.

Prof. RUCKER, in his reply, dealt very largely with the connection between theory and practice, and thought the practical man did not always give sufficient credit to the theorist, and would be glad to see a closer intimacy between the various learned societies.

Prof. W. E. AYRTON, in one of his inimitable humorous speeches, gave the toast of "The Engineering Societies," to which Sir F. BRAMWELL replied, pointing out that the year of his birth corresponded with the year of the birth of the Institution of Civil Engineers, and that the framers of the rules of that institution had very wide and broad views which had not and would not be departed from. The Institution of Civil Engineers held out the right hand of fellowship to all engineering societies, placing so far as possible the rooms and resources of the institution at their service.

Mr. LATIMER CLARK proposed "The Guests," informing those present that they had with them one of their honorary members, Mr. Jacob Brett, who was connected with the early work of submarine telegraphy, in the laying of the Dover-Calais cable in 1851, and who in those early days suggested an Atlantic cable.

Mr. A. MORLEY, acknowledging the toast of "The Guests," proposed by Mr. LATIMER CLARK, expressed the opinion that no commercial undertaking, certainly no department of the State, was more dependent upon or interested in the successful development of electricity than that branch of the service with which the President was connected, and over which he himself had the honour to preside. It was common knowledge that the success of our telegraph and telephone systems was dependent upon the successful utilisation of electrical currents, and he did not think he claimed too much when he said, with regard to the first of those services, that we had at least taken the foremost place among the nations of the world, even if we were not entitled to claim that we had surpassed all other nations on both sides of the Atlantic, and that we had provided a service which was superior to that of any other country. A series of almost unprecedented storms had lately been experienced, and he was glad to be able to report that the telegraphic service of the country had almost without exception been uninterrupted by those serious disturbances. It was not so with some of our continental competitors, and two days ago, speaking telegraphically, we had once again absorbed Calais within the empire of Great Britain, because all telegraphic communication with Calais was for a time entirely suspended, except by the wire which connected Calais with London. He did not know that he could say so much with regard to our telephone system, but he had very little doubt that the time was not far distant when that system would be equal, if not superior, to the telephone of any other country. The right hon. gentleman referred to the benefits which had resulted from the introduction of the electric light in the General Post Office, and mentioned that trials were now being made there with an electrical machine which defaced stamps at the rate of 560 or 580 a minute, as compared with 150 a minute defaced by the old method.

Mr. MUNDELLA proposed the toast of the evening, "The Institution of Electrical Engineers." He took occasion to mention that the excellent work done by the Electrical Standards Committee had been approved generally by electricians throughout the world. France, Germany, and the United States were prepared to adopt them, and he was so much encouraged by all he heard of the prospects of an international arrangement that it would shortly be his duty to submit an order in Council to her Majesty adopting the electrical standards as the standards for this country, and he hoped for the civilised world. They were making progress in this country with respect to electric lighting, for whereas when he addressed them last year there were only 26 local authorities which had obtained orders approved by the Board of Trade, now there were 46 local authorities in that position and 62 companies. He acknowledged the indebtedness of the Board of Trade to the Institution, and cordially desired the development and extension of its operations. There was room for a good deal to be done in England, for example, in the way of extending electric railways. Hitherto progress in this direction was slow, but he read the title of the draft rules to be considered by the Board of Trade (given in full elsewhere in this issue), which before agreeing to he would probably submit to the Council of the Institution for suggestions, and he hoped that the way would thus be paved for more rapid progress.

The PRESIDENT, in reply, said it had been his lucky fortune to have been instrumental in introducing the Institution to nearly all the wonderful developments of electricity that had so singularly distinguished this last half of this Victorian age, and this was greatly owing to his frequent visits to that energising country, the United States of America. In only one branch of electrical industry could we compare favourably with our American cousins, and that was in telegraphy. We were certainly ahead of them in that field, but in every other branch, especially telephony, we were behind in material progress, and we had very much indeed to learn from their rapid advances and their practical ways. But our advance, though slow, was sure, and he was not quite sure that we should not win in the long run. He touched upon the growth of electric railways and the electric light, and claimed that the electric light was the poor man's light. The trouble experienced was not that it was too dear, but that it was too cheap. The growth of the Institution of Electrical Engineers was shown by the fact that the total number of members of all classes on January 1, 1873, was 352, while at the present time it was 2,260, and the average number of members elected annually during the last six years had been 225. The Institution dealt with the present, and its object was to collect facts, to circulate truth, to cement friendship, and to provide for its scattered brotherhood a local habitation and a name.

THE ELECTRICAL TRANSMISSION OF POWER FROM NIAGARA FALLS.

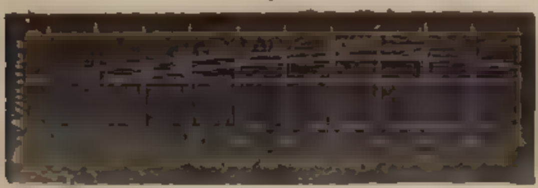
BY PROF. GEORGE FORBES, F.R.SS. (L. AND E.), MEMBER.

(*Continued from page 473.*)

It will be well at this point to say something about the frequency which is required to prevent the arc and incandescent lamps from flickering. I have made a number of experiments on these points, and my conclusions are as follows: A 16 c.p. 50 volt incandescent lamp shows a flickering almost up to 25 periods per second, at which frequency the flickering ceases when at its normal brightness, but if pushed to an excess of incandescence, the flickering was just perceptible up to 27 or 28 periods. I believe that a 100 volt 16 c.p. lamp shows a perceptible flicker up to 28 periods; but I may mention that this flicker is not nearly so serious or perceptible as that which frequently arises from the employment of certain types of engines, especially single-acting high-speed engines, when sufficient flywheel momentum is not provided. As a case in point, I would mention the lighting in the Holland House, one of the best hotels in New York, where, to an experienced eye, the flicker of the lights in the large dining-room from this cause is very objectionable. The thinner the filament, the more liability is there to such a flickering. I have lately examined the thick filament lamps to which the name of "Bernstein" lamps has been given, which consume six to ten amperes at low voltage. It takes so long a time for the incandescence to die out when the current is stopped, that I have little doubt about their being able to work without any perceptible flickering at so low a frequency as even 16 periods per second. I have also made some experiments of a similar nature on arc lamps at low frequencies. At 37½ periods per second there was a very bad flickering, and this was most noticeable when looking at a piece of white paper illuminated by the naked light, or when looking at an opal shade put on the lamp. At 40 periods it was still bad. Neither at this speed, nor at the previous one, was there any serious noise but at 40 periods the noise could be perceived by putting a glass globe over the lamp resting on the metal framework directly. At 41·7 periods there was just enough flickering to be objectionable; at 45 periods it was just possible to notice it on a printed page held close to the lamp, but it was not visible when reading at a distance of 10ft. At 50 periods the only means of detecting anything of the sort was by looking directly at the arc; nothing was seen when reading a book either with the opal shade on or off. At this frequency the noise became much more perceptible, especially with a long arc about one eighth of an inch. On reducing the length of the arc to one sixteenth of an inch the noise was much less. In all these experiments the consumption of energy was at the rate of 26 volts and 14·2 amperes at the lamp terminals. The best cored carbons of Siemens and Halske were used.

An objection has been raised to the use of low frequency owing to the fact that a periodical twisting strain is given to the shaft of the dynamo, but this objection disappears almost entirely when we are dealing with a machine generating two phases.

It follows, therefore, that for arc and incandescent lighting at a very low frequency it becomes necessary to use alternating current motor generators, or else to use something of the character of a commutating machine to convert into continuous current. Such machines as those exhibited by Schuckert at Frankfort in 1891 are useful up to a certain extent, but they are expensive, and comparatively inefficient, as their only function is to commutate the current—an operation which ought not to involve any significant loss. At the present moment a good commutator for the alternating current is not upon the market, but the matter is of such prime importance that I feel confident that much will be done in this direction. In fact, I have seen enough with my own eyes to have no fear about our being able to generate continuous current from the two-phase alternating current without serious loss, and with very inexpensive machinery. If, however, the object of our work was mainly, or even to a considerable extent, to provide the means of lighting towns by arc and incandescent lamps, I should have hesitated to recommend a reduction in frequency below 42 periods per second, such as is used by Ganz and Co., and which is operated so successfully at Rome and Tivoli, and at a very large number of other places on the Continent. The officers of the company and myself considered this matter most carefully, and, looking at the purposes for which our machinery is being set up, we felt sure that the proportion of electricity which would be used for lighting purposes would not be large, and that we must look upon our whole plant as a power producing and distributing plant, and that our object must be to distribute power in the most efficient and economical manner. This being the case, we agreed that it was desirable to lower the frequency so far as the mechanical conditions of the problem would allow. The lowest frequency which had been offered to us by the manufacturers was a very beautiful design of a machine at a frequency of 20 periods per second. This machine had admirable qualities, but was in some points not exactly adapted to the requirements of the situation, as developed by the selection of a special design for the turbine.



Tests made of a Three Phase Motor at 41 Complete Periods per Second and at [illegible], at 66 Periods per Second. [illegible]

I have myself made several trials of designs at very low frequencies, even as low as 8½ periods per second and for this frequency I prepared drawings of a machine which, though by no means perfect, shows a possibility of being worked into a sound machine of good mechanical construction; but further considerations led me entirely to modify the design of the machine, and eventually I arrived at the conclusion that, both from the point of view of design of the dynamo, and also for suitability of applying the current, 16 periods per second was probably as good as could be obtained. The manufacturers to whom the contract has been given were anxious to use a lower induction in the iron of the machine than that which I would have preferred, and this rendered the machine at 16 periods per second heavier than could be supported by the hydraulic piston which supports the whole weight of the turbine, vertical shaft, and revolving part of the dynamo. Consequently we have made a compromise, and are going to build our first three dynamos with a frequency of 25 periods per second. In concluding my remarks upon low frequency, I must again repeat that, from a purely practical and commercial point of view, one of the great advantages lies in the fact that for any special purpose for which a motor is required any ordinary direct-current motor may be altered so as to act as a synchronising alternating motor at a very small expenditure of time and money.

Electromotive Force.

The question of selecting a suitable electric pressure for working to Buffalo, and also for local purposes, is of some importance. Generally speaking, it is desirable to use as high an electric pressure on the line as is consistent with safe and continuous working, as this effects a great saving in the amount of copper used on the line. In the first report, founded on insufficient data, which I wrote more than three years ago for the Cataract Construction Company, I recommended that 2,000 volts should be used in the neighbourhood, and that the pressure should be raised by means of transformers for the more distant transmission. But the greater portion of our work in the immediate future will have the character of distant transmission. In most of the tenders which were submitted to us the cost of transformers were almost as much as that of dynamos, in some it was more, so that the use of a step-up transformer for distant transmission meant almost double the cost of generating the current. I hold the view that a pressure of even 20,000 volts can be generated as safely in the dynamo machine itself as in the transformers, and that if we used 20,000 volts for the local work as well as for Buffalo we should not be incurring the additional expense and losses of a step-up transformer, while we should be saving enormously in the cost of copper. Unfortunately, American manufacturers have never supplied alternating current dynamos at a higher pressure than 2,000 volts, and they are not practically acquainted with the experiences which have been gained in Europe at extra high pressures. Most of the manufacturers declared their inability positively under any conditions to go above 2,500 volts, although some of their engineers were willing to go as far as 5,000 volts. This, however, would have been no material gain to us; and the consequence is that to meet the views of the manufacturers in our preliminary work—that is to say, in the construction of the first three dynamos for our power house—there will be only of such electrical pressure as they are accustomed to deal with. We shall therefore be using dynamos generating current at 2,000 volts, and employing step-up transformers for the extra high pressure. This may possibly render it desirable in our first work not to use the extra high pressure for local purposes. Besides the actual cost of the conductors, a very serious matter arises when we are dealing with the large currents due to comparatively low electric pressure. I refer to the large quantity of copper which has to be put into the conductors. Working at 2,000 volts, each phase of each of our generators will give nearly 1,000 amperes, without considering the effects of retardation of phase, which will increase the current by quite a perceptible amount. So that, to put in the most economical section, will require 3 square inches for each conductor or 12 square inches of copper for each 5,000 h.p. dynamo, or 36 square inches section of copper for the 15,000 h.p. which is now being supplied. When we remember that even with low frequency the question of skin resistance comes into play when the conductors have a large diameter, it is obvious that we are introducing serious troubles, and if a subway were to be made to carry these conductors it would require to be of very great dimensions. For these reasons I am still anxious to see the extra high pressure used even for the factories within a distance of a mile. The uniformity of the system would undoubtedly be of great benefit to us if we could generate the whole current for all purposes at the same extra high electric pressure, but, as I have stated, we were obliged to content ourselves with a somewhat less perfect arrangement than would be adopted if we were dealing with the utilisation of a waterfall in Europe.

I wish to lay stress on the importance which I have considered to lie in the fact of having a perfectly uniform system with interchangeable dynamos. Many engineers to whom I have talked have suggested the use of special dynamos at different pressures for special purposes; but if we had a special dynamo for arc lighting, and another for incandescent lighting, a third for street railways, another for electro deposition, and so on, the possibility of interchanging dynamos would disappear and the whole system would be much more complicated to work.

I wish now to make a few remarks about the insulation which it has been customary to put upon dynamos and transformers which were to be used with high electric pressure. Many persons who have not given sufficient attention to the subject seem to be inclined to believe that there is something mysterious about the tendency of electricity in a dynamo or transformer to break through the insulation, and which prevents them from being subject to the ordinary laws of electricity. Thus, when building a dynamo for 2,000 volts a thickness of insulation is given which would stand a test of more than 100,000 volts without breaking down, and it has been found from the ordinary methods of using the plant that if something of this sort is not done the insulation will break down. I wish to point out that the reason for this lies in the fact, not that the insulation breaks down with 2,000 volts, but that in a 2,000-volt system as generally used E.M.F.'s are occasionally generated amounting to 100,000 volts or more. These abnormal rises in electric pressure are chiefly due to the resonant effect, which has received so much attention of late years, and may be caused by the sudden breaking of the circuit of the dynamo. If these causes of excess be avoided, the electric pressure will never rise above the working pressure, and the insulation will never break down, even though its thickness be only little more than sufficient to stand a test at the working pressure. Dr. Fleming has shown us how to kill the resonant effect, and such a phenomenon never appears now at Deptford. This trouble may also be avoided by having as little capacity on the line as possible, especially when combined with low frequency. As to the cause of trouble mentioned above, I hold that it is a piece of culpable ignorance, ruinous to the machinery, if anyone should ever on a large power circuit with alternating current, suddenly break the circuit while current is passing. This practice is quite unnecessary, and has given rise to a large proportion of the breakdowns of alternating current machinery.

Parallel Working.

Engineers in America have had no experience in actual commercial conditions of parallel working with alternators. This is partly because the machines which have been made in that country do not work so well as some others in parallel. In the case of the transmission from Niagara Falls my opinion is that parallel working will give the best results. If this arrangement were not adopted it is obvious that when the dynamos are loaded up as much as possible they could never be all fully loaded. It is also quite obvious that if our conductors are to be carried through subways, the space required becomes quite excessive unless we adopt parallel working. The complete success of parallel working between Tivoli and Rome left no doubt as to the feasibility, besides the desirability of adopting parallel working. The reduction in frequency which we have made assists very considerably in this result, and it says much for the American manufacturer who has received the contract that, although parallel working with

multiphase machines has not been adopted in the past, he is ready to guarantee the performance in this respect of the machines which are to be built for us.

The rules which govern the construction of machines which shall work well in parallel are not very clearly understood. The only fact which has been perfectly established in practice is that the lower the frequency the more efficient and sure is the parallel working. It certainly depends to some extent upon the amount of self induction and the amount of mechanical momentum in the machines. It is also certain that if the self induction of the machines is too high they will not work well in parallel. Of all machines which have been constructed, those which work the best in parallel appear to be those of Ganz and Co., Mordey, and Elwell Parker, but there are many others which do extremely well. It is, at present, not possible to state exactly the conditions which are necessary, but I may say that generally a machine with a stiff magnetic field works better than one where the iron is far below magnetic saturation. In judging whether a machine of a particular type will or will not work in parallel, I think one must be generally guided largely by one's own personal experience in the matter, combined with a knowledge of the effects of self-induction, mechanical momentum, and magnetic saturation as deduced from theoretical considerations. I do not think that anyone who knows anything of the working of the Tivoli Rome plant would for a moment hesitate in saying that on a large and important station like that at Niagara Falls parallel working is essential; and this is the opinion of Prof. Mengarini, who has so ably directed the works at Rome.

Motors.

Under this section it may be as well to discuss some of the different purposes for which the electric current will be required. With regard to arc and incandescent lighting, if the frequency be high enough, the current can be used directly for this purpose; although most people would prefer that, in the case of arc lighting, the current should be commutated or converted in some manner so as to give a continuous current. That this is unnecessary, however, is amply proved by the perfect success of the arc lighting by alternating currents in Rome, and many other large cities, especially those which have been established by Messrs. Ganz and Co. At the present time one of the largest applications of electricity in the United States is for street railways, which require a continuous current. Another similar purpose which we shall have to consider is the application to canal boats, since it is intended to work the Erie Canal by electricity. This canal starts from the Niagara River, and reaches the Hudson River at Albany, 350 miles distant. For these purposes some sort of commutator or motor transformer will be desirable. Some of the first work which will be done is the supply of much direct current at 150 volts for the production of aluminium. This also requires the continuous current, and similar means must be used for obtaining it. Among the large class of mills which will be established at Niagara Falls, one of the most important kind is wood pulp mills, one of which is already working on our land, and will be the first to receive water power from our canal. This type of mill uses many thousands of horse-power, and is worked continuously day and night. In this feature it resembles, probably, a large number of the mills which will take advantage of the cheap power at Niagara Falls. Such mills are working continuously day and night, and do not require to be ever stopped or reversed. This is an important class of work in our case, because current can be supplied to such mills by means of synchronising alternators whose efficiency is extremely high, and this may perhaps be done in some cases without transformers. We require also to consider the case of small motors for use in shops, and for elevators, cranes, and a large number of other purposes. In this type of motor frequent stoppages and reversals are necessary. Hitherto, direct-current motors have generally been employed for this latter purpose, but the rotating-phase induction motors are distinctly suitable, and when these have been fully developed they will probably be largely used for this purpose. The commutated current is a thing which is sure to be in common use before long, and although our arrangements at Niagara Falls are perfectly complete without a machine for this purpose, still its employment has been considered by us, and the probability of its future use has influenced our judgment in some points. There are so many purposes for which the direct current is most convenient, that people would generally accept it for transmission if it were capable of being economically transformed up and down to different pressures. The direct current dynamo is really an alternating dynamo with a commutator placed upon it. If the commutator, instead of being placed there be placed in the neighbourhood of the motor, we obtain most of the advantages both of the continuous and of the alternating current. This is one of the advantages of having two phases generated by the dynamo, because it is much easier to rectify a two phase current than a single phase current. In addition to the motors above specified, there are a large number of single phase motors which start with a powerful torque which have been invented by different electricians, but which are not yet put upon the market. There are also machines with commutators like a direct current dynamo with laminated field. These all become very efficient and useful when the frequency of alternations is sufficiently diminished.

Line Construction.

A great deal of attention has been given to the different methods by which current can be conveyed to the points of consumption, whether on our own property or at Buffalo, or even further. Naturally the pole line was first dealt with, in which the poles might be constructed of either wood or iron. This is the cheapest type of construction, and has some advantages, but we must consider the climatic conditions in the neighbourhood of Niagara Falls. We are subject there to severe thunderstorms, and troubles from lightning have already been serious in several parts of the United States in connection with electrical machinery. Snow and frost are very severe, and sleet forming upon the wires and insulators may cause a great amount of trouble. There are also at times very violent gales sweeping from over Lake Erie. All these difficulties can be counteracted to some extent, but it is nearly certain that with overhead construction occasions would arise when the continuity of operations would be interrupted, and this would be a very serious matter. The next system to be considered in order of cost would be underground cables, but I am strongly opposed to the adoption of these for any considerable length. It is true we are able to deal with their capacity so as to reduce its injurious effects, but surely the best plan of all is to abolish the capacity itself as far as possible. The most satisfactory method of proceeding is to build a subway of sufficient size to enable a person to walk along it and to carry bare copper conductors in it, but this is a matter of considerable expense. I am glad, however, to be able to inform you that the officers of the company resolved last summer that a subway such as I have described should be constructed from the power house up to the Pittsburgh Reduction Company's works, where aluminium is to be produced, a distance of 2,500ft. In accordance with their instructions, I prepared plans, which are now exhibited, and which give space enough to carry the conductors at 20,000 volts for all the power that will be developed by the present tunnel, parallel working being adopted. The subway is built of concrete, having a minimum thickness of 10in. The height inside is 5ft. 6in. Wooden beams are embedded in the concrete on both sides every 30 feet. When the concrete is set, these beams are removed, and iron castings for supporting the brackets that hold the insulators are put in their place and these are then grouted in. Iron brackets as shown in the drawings are bolted to these castings and the oil insulators placed upon them. Copper wires are shown as being supported on these insulators, but we shall probably adopt copper strip. The bottom of the subway is always on an incline, and is of curved shape to drain off any water of condensation, but it is also proposed to force air through the subway so as to keep it dry. The 2,500ft. now being completed is all drained at the power-house end by a boring into a water bearing stratum. At the bottom of the subway the concrete is formed in two steps, the lower one of which supports sleepers for a very light tramway upon which a truck can run to carry supplies, and also to carry the inspector. At first this can be moved by a hand lever, but arrangements are made for eventually driving it by electricity, the conductor being carried on the floor, between the stringers (placed on the ties or sleepers), which form a platform running along the length of the subway. On the stringers outside the rails is placed a screen separating, mechanically and electrically, the part of the subway where the conductors are from the part where the inspectors walk. This screen is formed in 10ft. lengths of wood supporting expanded metal, covered over with plaster up to a height of within 1ft. of the top, the upper part being left open in the form of a network, through which the inspector can look at the conductors and their supports. These screens are held by iron supports fixed by expanding bolts into the concrete, and can easily be removed. The top of the arch is 3ft below the surface of the ground, so that it will not be affected by frost. According to the last report, it appears that on the 21st of October 1,590ft. of this subway had been completed; the total length being put down at present is 2,500ft. Each of the iron castings has a wire attached to it which passes through the concrete, and is soldered to a copper wire running outside the subway along its whole length, and connected to a plate sunk in the water at any suitable points. At every 400ft. cross streets will be made, and at these points there is a manhole. Also at these points, on each side of the subway, four drain-pipes, 3in. in diameter, are let in, closed at their outer ends. When the subway is to be tapped for use on the side streets, or for intermediate points, wires can be laid through these points. Between Niagara Falls and Buffalo there is very little rock, but the part where the subway has now passed through has been chiefly in rock. This involved blasting out a channel larger than was required. In this case the part of the trench outside of the subway has been built up of stone. In the construction of this subway American Portland cement has been used, and a very suitable sand from the neighbourhood which contains its own gravel. The whole of this work has been done by Mr Humbert, and up to the date of my last inspection every part was thoroughly and satisfactorily done. This work is of great importance as conveying to the minds of those who intend to use our power some idea of the desire to ensure continuous working.

With regard to the electric pressure that is to be used for distant transmission, this will undoubtedly advance with experience. Some manufacturers in Europe who tendered for the work proposed to adopt 25,000 volts, which is a step in the direction of Lord Kelvin's suggestion of 80,000 volts; but we have considered that at present 20,000 volts is not likely to be exceeded by us, and we may work at a lower pressure at the commencement. When it is remembered that the Deptford machines have one terminal connected with the earth, and are working satisfactorily at 10,000 volts, and when it is noticed that, in consequence, our work would be under exactly the same conditions as regards insulation when working at 20,000 volts, it is easy to see that we are not risking anything experimental in our first work.

With regard to the size of conductors, I worked out the economical size at different current densities for the whole distance. In doing this I took the following data: I took the cost of copper

at 12½ cents per pound, and the annual charge on this cost at 5 per cent. I then computed the power loss in the line, and the amount of power which was left available for delivery. I took the value of this power at the distant end of the line as being 15dol. per horse-power. This is something more than what it costs us to produce it, but when the power available from our tunnel is nearly all consumed this quantity will have to be increased. It must also be remembered that I have not allowed for the increased size of the conductors required by the retardation of phase, which is an unknown quantity. Still, it will be seen that from these considerations we may be able to work economically at a slightly higher current density than is obtained from this investigation. From this work it appears that the most economical density to work at is 350 amperes per square inch. If this density is used, the fall in volts between Niagara Falls and the northern boundary of Buffalo is only 3½ per cent.—a matter which makes regulation extremely easy.

With regard to the efficiency of the system, it is remarkable how high the efficiency of the dynamos comes out when we are dealing with the large units of 5,000 h.p. There can be little doubt that the efficiency, electrical and mechanical of our dynamos may reach at least 98 per cent. Taking off 3½ per cent. for losses on the line, we would have 94½ per cent delivered electrically at Buffalo if no transformers were required to raise the electric pressure to the full 20,000 volts. In cases at Buffalo where the power consumed is very large, the motor can be constructed on the same principles as the dynamo; and if in this case it be ever possible to work at the full pressure without a transformer, it is obvious that the total efficiency of the system—that is, the power delivered by the motor to the shaft of the machinery divided by the power delivered by the shaft of the turbines to the dynamo—will be certainly over 90 per cent. As a matter of fact, if we were to use a higher density of current, and were to use step-up transformers at Niagara Falls and step-down transformers at the northern boundary of Buffalo, and other step-down transformers in the town of Buffalo itself, and were to use motors of small power, and consequently less efficiency—in this case the total efficiency of the plant might be reduced to 80 per cent., or even lower.

I have given these figures, not as indicating precisely the lines on which we have determined to work at Buffalo, but because the present paper is intended to embrace the subject of the general distribution of power, and I thought it desirable to lay before you certain facts in this connection in a definite form

Description of Machinery to be Used

Under this heading I shall deal chiefly with the type of dynamo which has been finally decided upon. It will suffice to say of the turbines that they are each of 5,000 h p., that they revolve at 250 revolutions per minute, and were designed by Messrs. Faesch and Piccard, of Geneva. All the principal parts of this machinery were constructed by the I. P. Morris Company, of Philadelphia, but the governors of the turbines are of Swiss manufacture, and part of the steel fittings were constructed in France.

With regard to the dynamo, the Cataract Construction Company at first invited many different manufacturers in Europe and America to submit plans. The number of these that were submitted altogether amounts to 24, some of the manufacturers having taken a great deal of trouble to submit a series of designs, in order to be able to meet different requirements. Many of these designs were extremely good; but it was determined, after estimating the increased cost of using the European designs, owing to the high tariff in America, and owing to transport, to have the machines manufactured in America. Among the designs from American manufacturers there were none which fulfilled all the requirements of the case, and eventually the Cataract Construction Company decided to get out their own designs, and to submit them to the American manufacturers for tender. I had been for some time previously engaged in working out a design which I am confident none of the manufacturers who had sent in designs could say was in any way borrowed from their ideas. We had received suggestions of an external armature with internal revolving fields, and also of external fixed fields and internal revolving armature. We naturally had a preference for a dynamo with a fixed armature, because the coils can be more securely wound, and are not subjected to the mechanical stresses induced by centrifugal force. But all the designs with revolving fields which had been submitted to us contained a weak feature. The field coils were held in by pole faces secured by bolts or keys to the poles, and this seemed an element of weakness when we considered the enormous centrifugal forces to which the machinery would be subjected. At the same time, the turbine makers had insisted upon having a certain momentum, or flywheel effect, which was not given by the revolving parts of any of the dynamos submitted to us, and it was found that if any one of these had been accepted it would have been necessary to add to the design a flywheel of large dimensions. Centrifugal force was one of the most important matters to be considered, because at 250 revolutions per minute this force assumes a considerable magnitude in the large masses with which we had to deal. Moreover, in all the designs which had been submitted, the magnetic pull between the poles and the iron of the armature assisted the centrifugal force. The principal feature of the design upon which I was working consisted in having the armature fixed, and inside the machines, with the fields revolving outside; the fields being formed of a ring of iron with the poles projecting radially inwards. One advantage is that we are able to get the full flywheel effect that was required by the turbine-makers. This requirement was *that in the revolving part* the sum of the weights in pounds of each part, multiplied by the square of its velocity in feet per second, should equal 1,100,000,000. The design also gives an extremely good mechanical construction for the revolving parts. The iron ring which forms the yoke of the fields serves as a support to hold in the pole pieces and the exciting coils, and no part is held in against centrifugal force by bolts or keys. Moreover, the magnetic pull between the fields and the armature acts in opposition to, and does not assist, the centrifugal force. The armature is fixed, and a large space is available inside it for the workmen to attend to the bearings, and to reach any part of the armature. It is obviously possible to insulate the armature coils for any electric pressure. With a large machine of this kind the space occupied by insulation has not the same importance in reducing the output of the machine as is the case with machines constructed in the past. In fact, the armature coils can be wound with the same insulating properties as a transformer, and hence the necessity for using a step up transformer can be avoided.

Starting with this general principle I first got out designs of a machine at 33 periods per second, in order that I might compare the general appearance of such a machine with those of other types. The next point was to design a machine of as low a frequency as was possible under the limiting conditions as to weight. The revolving parts of the turbine and dynamo, and the shaft connecting them, are supported by a hydraulic piston, and it was the desire of the Cataract Construction Company not to use a thrust bearing of any kind to support the weight, although there is a thrust bearing at the top of the shaft, which simply acts to retain the apparatus in a fixed position in a vertical direction. Owing to this decision, it was necessary to limit the weight of the revolving parts of the dynamo to 80,000lb. In getting out the design for this machine it was desirable to select such a form of winding as past experience led one to believe would be most efficient for parallel working, and I judge from past experience that this is best attained by having the number of coils per pole very small. The 33 period machine which is shown in the drawings has only been sketched out with a view of getting at the general dimensions of the machine. It is not suitable for our special purpose, because it is essential that, without taking the dynamo altogether to pieces, we should be able to lift up through the centre of the dynamo any parts of the turbine shaft which may require repair.

It will be seen that from the necessities of the case at Niagara Falls the dynamo which was required differed in some respects from what would be necessary in many other cases, but it is equally obvious that in any case of so large a transmission of power the conditions must be thoroughly considered beforehand, and the dynamo specially designed for the purpose. At the meeting of the board of directors of the company, in May, 1893 I was instructed, with Dr Sellers to get out plans for an alternator of the type which I have described. I am not able to lay before you now plans of the machine as it had been finally adjusted by conference between ourselves and the manufacturers. In the plan which we prepared, the frequency was 16⅔ periods per second, there being eight poles. The armature coils were so wound that they might be connected to give either 2,500, 5,000, 10,000, or 20,000 volts, and the coils were limited in number so as to give the best assurance of good parallel working. For various reasons we decided eventually to raise the frequency to 25, and to lower the volts to 2,000, without the means of connecting the coils to give a higher pressure, and instead of winding the armature on the conductors in a limited number of coils, to adopt the methods more commonly used in some of the large types of generators. But since in any future work which is done the dynamo will be required to be modified for the special purpose, a description of the machine—of which I am able to show you the drawings—is sufficiently representative of the type of machine for our purpose.

General Description of a 5,000 h.p. Alternator.

On the bed plate a vertical cylinder is bolted, with projections to support the fixed armature and the bearings of the revolving part. The armature coils are wound independently, and can be removed and changed. They are fixed in slots in the fixed armature. They are encased in an oil-tight casing, through which oil can be circulated. The field magnet is external to the armature, and has the poles pointing radially inwards. It consists preferably of forged steel supported by a spider with eight arms which may be of steel with a covering of thin sheet metal, on which cups are provided for forcing air into the interior of the machine. The pole pieces are bolted on to the steel rim. The field coils are of copper strip, two coils being wound upon each pole, with a space between them for air circulation. The exciting current is applied by rings of tempered copper on the spider, having fixed brushes rubbing on them. The hub of the spider is firmly fixed to the upper end of the shaft. The spider supports the heavy rim by 16 studs and nuts. The shaft is supported by two bearings, each of which has four radial arms, which are bolted to four corresponding projections on the cast-iron cylinder. This cast-iron cylinder is bolted to the bed-plate and adjusted thereon by wedges. Besides having on it the projections for carrying the bearings on its inner side, it has on its outer periphery a series of vertical ribs, against which the stampings, or sheets of iron forming the armature, rest. It also supports the lower end plate on which the armature is built up, and the armature is keyed to it by a single key. The armature is wound drum fashion—that is, all on the outside. This enables the coils to be wound independently and laid in their place, and also to be easily replaced in case of accident. In order to do this satisfactorily, the slots for each coil in the iron are cut, not radially, but parallel to each other. Each coil is encased in insulating material, which forms a tube through

which oil may flow, as in a transformer, but may be forced, in which case its circulation is maintained by a pump. Round the base of the machine there are two oil pipes, one being the inlet and the other outlet. The inlet pipe is connected with a reservoir of oil in the power house. The outlet pipe leads by another pipe to cooling arrangements in running water, from which the oil is pumped to the reservoir. From the inlet pipe 16 brass tubes are led to the junction boxes at the bottom of the 16 coils; the 16 other brass tubes are led from the junction boxes at the top of the coils through the interior of the fixed armature and bent over the foundation plate, and so connected to the outlet pipe which surrounds the bed plate. The bed plate is a single iron casting, and in order to enable it to be transported over the railways it was necessary to limit its diameter as shown in a supplementary drawing, which shows the improved oiling arrangements, which were worked out by my chief draughtsman at Niagara Falls, Mr. Baumann. The armature is built up of thin sheet iron, with ventilating spaces, as shown on the drawing. The bolts which hold the armature together are eight in number, to be made of nickel steel, a metal which has the great advantage of being non-magnetic, and of very high electrical resistance and great mechanical strength. The amount of nickel is 25 per cent. There are 16 armature coils, eight being of one kind, called "short" coils, and eight of another kind called "long" coils, the length of wire on each coil being the same. The short coils are bent over at the end plate, and the long coils are wound in one plane and enclose the short coils. I find that if we are to have a very stiff field, with first-class quality of iron in the fields, each coil would consist of 72 turns of pure copper wire, No 0 of the Brown and Sharpe gauge, which gives a very low density of current and reduces the heating. In fact, it has been my view that in designing the machines for so great and permanent a work every effort should be made to reduce the rise in temperature, even to far below what has ever been done in the past. The unequal expansions and contractions of materials in a machine of this kind are very injurious to its permanence, and affect the insulating material seriously. The layers of wire in the coils are separated by mica. Each coil when wound has strips of insulating material laid spirally round it, so that oil may circulate freely in the intervals, and the whole is encased in a casing of strong insulating material. The material which I prefer for this purpose is certainly woodite, an eighth of an inch of which will not break down with 30,000 volts, and which is not acted upon by oil even at high temperatures. I have a record of tests with oil which are conclusive on this point. It is quite the best material I have seen for the purpose, though costly, and, being a secret process, it may be difficult to ensure uniformity. The frames of the bearings are of cast iron, with four radial arms, which rest upon four projections cast on the vertical cylinder, and are bolted to them. By this means, when the field magnet with the shaft have been lifted out of place, the bearings can be twisted through an angle of 45deg. in a horizontal plane and then raised out of place, leaving a space 5ft. in diameter through which portions of the turbine shaft can be raised for repair. The bearings are oiled at the centre by oil forced under pressure through a pipe. The oil is then distributed over the bearings by spiral grooves. A spiral groove is also cut in the hub of the frame, with a pipe at each end to admit of water circulation to cool the bushing. At two opposite sides of each bearing the bushing is made thin, and a rod of bismuth is soldered thereto; so that if the bushing is heated a thermo-electric current shall be created which, by means of a relay, can ring a bell in the power house. When this occurs, water can be immediately admitted to cool the bearings, and the attention of the workmen is drawn to the necessity of an examination. One of the parts which required most consideration was the material of which the spider supporting the field magnets should be constructed. The best plan is to make it of steel, for the sake of lightness, and to cover it with a copper covering, which might, I think, be spun; or, perhaps better, electro-deposited nickel might be used. Between the pole-pieces the space is filled up with a screen or plate of metal so as to direct the air ventilation only upon the parts which most require cooling. The methods finally selected for oil circulation are shown in a separate drawing.

(To be concluded.)

Institution Meeting, November 23.

MR. W. H. PREECE, F.R.S., President, in the chair.

At last night's meeting of the Institution the following candidates were balloted for:

Members.—Thomas Octavius Callender, 101, Leadenhall street, London, E.C.; Ormond Higman, Ottawa, Ontario, Canada; Thomas Preece, 102, Preston street, St. Andrews Villas, Bradford.

Associates.—Arthur Ellis, Cambridge Electric Supply Company, Limited; John Gordon, 51, Main-street, Rutherglen, Glasgow; R. C. Holness, 3, St. Martin's road, Stockwell, S.W.; Frederick W. E. Jones, Midland Electric Light and Power Company, Leamington Spa.

Students.—Ernest Arthur Bayles, Barwood, Caterham Valley; Hugh Capper Crawhall, Faraday House, Charing Cross road, W.C.; William Alan Fraser, 121, Adelaide road, N.W.; Herbert William Miller, Faraday House, Charing Cross road, W.C.; Drogo Montagu, 2, Redburn street, Tedworth square, Chelsea, S.W.; Evelyn Henry Terrell, 104, Philbeach-gardens, Earl's Court, W.

The reading and signing of the minutes and the ordinary formal business having been carried out, the **President** rose, and in a few brief and touching words referred to the loss which the Institution had sustained by the death of Mr A. Reckenzaun; and on the proposition of **Mr. G. Kapp**, seconded by **Mr Mordey**, it was resolved that a vote of condolence be officially sent by the Secretary to Mrs. Reckenzaun.

Prof. A. Fleming then commenced the discussion on Prof. Forbes's paper, and congratulated the Institution upon such a valuable contribution to its *Journal*. It was not often that engineers took the public into their confidence and laid open the plans proposed during the progress of a work, or, as it were, opened their minds, showing the inner reasons, and inviting criticism. He would confine his remarks to one or two points. The difficulties of transmission over long lines were very real, not of the fashion of professors' difficulties, and had to be overcome. It must not be assumed that the effects of capacity could be neglected. No doubt the choice of a particular type of line had been dictated by a desire to avoid those difficulties as much as possible, and to reduce the capacity effects. It was absolutely necessary to avoid the pressure effects which with alternate current distribution took place when lines were suddenly connected or disconnected from the machines. It was useless to talk of failure of insulation in those cases for the pressure effect was often such as no insulation whatever could stand, and therefore the pressure effect itself must be minimised or eliminated. Prof Fleming mentioned that the deleterious effect had been got rid of at Deptford by the engineer, Mr. D'Alton, after discussion with him. This was by the use of a transformer having in its secondary circuit a great resistance, which could be gradually thrown on or off. The apparatus required three switches, but in effect, by means of this transformer, a very great impedance could be obtained, say on making contact with the concentric mains. This impedance was gradually diminished, and so no harmful effects were found in the mains. The operations at breaking the main circuit were the reverse of those at the making. The speaker pointed out that the capacity of these cables was about ⅓rd of a microfarad per mile, and that as the damaging effect varied as the square of the current it could never be slighted, and was, in fact, often disastrous. These effects were increased by increasing the frequency, hence one reason for reducing the frequency as low as possible. Prof. Fleming then gave allegiance to the Continental plan of using an artificial resistance on putting machines in parallel, specially referring to the resistance at Tivoli, where some 300 horse power could be absorbed, which was about the output of one of the machines in use. He was sorry the system was not adopted in England. He also pointed out that there was a good opening for the invention of a main fuse for alternate current circuits, which, when the current passed a certain point, should put in great impedance, or, when necessary, take out impedance without ever absolutely breaking the circuit. He would like to know in Prof. Forbes' reply the distance between the conductors, because he feared the effect of arcing with a pressure of 20,000 volts, if they were too close together.

Mr. Mordey said that the practical experience of some differed from that of others; therefore it was of great value to obtain united experiences, so as to have something of settled character in practice. One great value in Prof. Forbes's paper was that it not only gave experience—it gave reasons. Probably they were all agreed as to the use of alternate currents for large power transmissions. He agreed generally with the scheme as put forward in the paper, but differed upon points of detail. He denied, for example, that parallel working was assisted by lowering the frequency. If there was no difficulty found in parallel working with frequencies of 100, why want to work at a lower? He ventured to ask if the reason put forward was correct, why Ganz used a periodicity of 42—viz., as that was the lowest which worked in parallel without flickering of the arc lamps. He asked this because, in a paper of his own, he quoted a published letter of Zipernowsky, which was contradicted in a subsequent communication from the same source. He thought it had happened that certain makers used a periodicity of 42 before parallel working was looking upon as important, then experimented and altered to use this periodicity even with parallel working. With regard to the artificial loading mentioned by Prof. Forbes, and approved by Prof. Fleming, he looked upon that as an obsolete system. It was used by Edison with the old "Jumbo" machines at Holborn, and was still used at Milan. It was utterly unnecessary, and naturally he preferred the method described in a paper of his as devised by himself and Mr. Raworth, which consisted in playing upon the field excitation and the steam regulation, and by which there was no difficulty with pressure or sparking. Even with machines with a big drop in the curve, no artificial load was required. He thought the system continued to be used on the Continent because it had become stereotyped, and was put in as a matter of course. He pointed out that the low frequency was not required for transformers.

Mr. G. Kapp thought that the Institution should be congratulated on the fact that one of its own members had been selected for this paper. Prof. Forbes in one portion of the paper discussed the merits of the number of phases—whether single, two phase, or three phase. When in America in the summer, the speaker conversed with Prof. Thomson about this question. The latter tried to convince him that three phases would require less copper than two, but he could not see it. When he returned from the States he investigated the matter, and then saw daylight on the subject.

(To be continued.)

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BOARD OF TRADE AND ELECTRIC TRACTION.

The Right Hon. A. J. Mundella, in his speech at the Institution dinner, referred to the progress of electric traction in this country. He explained that the Electric Powers (Protective Clauses) Joint Committee, in their report, suggested the framing of regulations by the Board of Trade in this matter, and that draft regulations had accordingly been prepared. These draft regulations are given elsewhere. It was stated by the President of the Board of Trade that the regulations would come before the Council of the Institution for an opinion before he would finally sanction them. We gather from this that the Board of Trade is desirous of obtaining opinions as to the perfectness of these draft rules, and those interested in the matter should therefore carefully examine them and communicate with the authorities. It must be remembered by those interested in tramways that if these rules are left uncriticised and are adopted, to change them will be difficult. The Board of Trade may then well listen to opposing interests and say, When the draft regulations were made public, no objection was raised: why wait till they are adopted? The criticisms to be of value must be before final adoption, and no doubt there will be little hesitancy in expressing criticisms. We are of opinion that in several particulars the rules will be found unnecessarily stringent, and if our supposition is correct, the Institution might, with great benefit to the industry and with credit to itself, set aside one or two evenings of the session for an open discussion of the whole subject. A discussion of this kind, if properly organised, would greatly aid the Council in giving an opinion upon the regulations. The electric traction people only want to live, and do not desire the extinction of telegraphs or telephones, or to conduct their lines so as to eat up their neighbours' pipes. We make this suggestion from an experience of years ago, when a learned society set aside a whole session for the discussion of a particular book. The benefit accruing from that action was acknowledged to be far and away above what obtained from the reading of papers. The Council might easily arrange for certain paragraphs to be discussed on a particular evening and obtain a number of speakers to discuss from opposite points of view. The Council at the end of the discussion would have all the facts and opinions before them, and would act as a judge in summing-up. Such summing-up would be their opinion to be delivered to the Board of Trade.

HALF TRUTHS.

If an inventive genius could patent some method of counteracting the effects of incorrect information, it might be a blessing to the world. Electric lighting has had a tough fight to establish itself as the coming illuminant. Its opponents have been many, its detractors not a few, yet gradually it has pushed its way. Had its properties not been good it would long ago have been snuffed out. Still, we must not for a moment imagine that its calumniators are dead or are withdrawing from the conflict.

They will fight to the bitter end, and are doing great damage by means of half truths as well as by deliberate falsifications. It is exceedingly difficult to get rid of the harm caused by these tactics; hence, while not agreeing with every action or word of such energetic men as Mr. R. Hammond, it must be conceded that his activity has done much to interest local authorities in matters electrical. We take him as a keen man of business, preferring to carry on a crusade in the enemy's camp rather than to wait a request or to repel an attack. He may in many qualities fall far behind other members of the profession, but undoubtedly he has the tact and the ability to make men believe in the possibilities of electric lighting, and, after all, this ability is quite as valuable as ability in other directions. We must somehow or other reach the ears and eyes of purchasers, and drive home the fact that the opinion frequently expressed about the cost of the electric light is wrong. From interested parties we are continually informed that companies have not paid dividends, that capitalists have lost money, and that it cannot be otherwise, because the cost of electric energy precludes favourable competition with gas. In making sweeping statements of this kind great care is taken not to give the exact conditions existing whereby to make the comparison. Over and over again it has been proved that electricity can compete with gas, and we ought to get rid of such statements as appear in the report of the Hackney Local Board, to the effect that "it would appear that at present electric light costs double, or almost double, the price of gas." That statement is wrong, and is just about the same as it would be to compare the cost of gas where a £500,000 gas plant was supplying one thousand gas burners, as against a similar electric plant supplying five hundred thousand burners. Now, condition for condition, and the electric light will beat gas hollow. It can compete with it in price, and in every other desideratum it is far and away the more preferable. A number of accidents attributed to electric lighting are due to gas. Both electric light mains and gas mains leak—the leakage of the former will do no harm, unless perchance the leakage of the latter gives it an opportunity. If there happens to be an accumulation of gas in culvert or manhole the insulating air may be turned into an explosive mixture, and electricity may act upon it; but electricity is no more to blame than gas, and the fact should be driven home to the minds of the public. We find another text in the report above referred to, that electric light "if adopted in main streets, as is generally the case, would benefit those streets, while the burden of extra cost would partly fall on streets deriving no benefit." Surely it is not quite fair to isolate each street in this fashion. The trade of a whole neighbourhood is in its principal streets. These streets, again, are common property, used by every dweller in the side streets, and it is important for the welfare of the dwellers in side streets that they should have well-paved and well-lighted principal streets in which to carry on business and travel. The principal streets are usually better paved and better lighted than the side streets, and we never yet heard townspeople or residents murmur that this was unjust. If we take the Metropolis, who benefits by a well-lighted and paved Oxford-street? Not the residents in Oxford-street only, but everyone who comes to do business there, or who passes through the street to business or to his home. These and many similar questions can and should be discussed by those who are in a position to enlighten local authorities and the general public. The technical journals are fairly powerful with the former, but the constituents of the members of the various authorities they cannot reach.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

MOTOR GEARING FOR ELECTRIC TRAMCARS.

SIR,—Referring to your article on "Motor Gearing for Electric Tramcars" in your issue of November 10th, p. 441, your statements hardly give the credit due to leather link belting, and I have *not* abandoned it in favour of worm or any other gearing. For piers and level roads generally where it is clean ballast, and an edge rail can be used, I should continue to use it. There is an entire absence of noise, and any defects can be seen in time to be remedied; the motor can be entirely supported by the car framing, so that the springs carry the weight, and the rail hammering which occurs when motors are hung on the axles is entirely avoided. Of course, worm gearing is also noiseless.

But a very important matter is the question of power. With our two leather belt driven cars our 12 h.p. gas-engine can start both at once with the heaviest load of passengers owing to the slight slip of the belt allowing the motor to ease ahead a little when starting. With the worm wheel driven cars, one takes all the power of the engine to start it, although when fairly under weigh it takes no more current than the old belt-driven cars, so that for small, clean, level tracks this consideration is important.

I should not advocate belts for hilly and dirty routes. Flat solid belting is quite useless for the short drives and small pulleys obligatory in tramcars.

The quietness of belting is also an important matter, and must not be overlooked; and after 10 years of experience, any new cars I have for this road will be belt driven.

To show that the traffic dealt with is considerable, it may be mentioned that it equals 170,000 persons per car per annum, with a maximum of 3,250 persons per car per day (bank holiday), which with a 12-h.p. old type gas-engine is not bad.—Yours, etc., MAGNUS VOLK.

Volk's Electric Railway, Brighton.

[It will be seen that Mr. Volk's remarks, though very interesting, do not seriously contradict the statements made in the article above mentioned. The lines intended to be discussed therein were more especially those upon roads and streets, or public highways generally, and not so much the enclosed railways on piers or in places where other wheeled traffic is absent or unusual.—THE WRITER OF THE ARTICLE.]

ELIESON ACCUMULATOR (BRITISH PATENT) SYNDICATE, LIMITED v. THE EARL OF GALLOWAY.

SIR,—Will you allow me a small space in your issue to correct an impression which has been created that I am connected in some way with the plaintiffs in this case?

In July, 1892, I gave an option to acquire my patent for electric accumulators during a period only of 60 days and upon the terms that a company should be formed having a subscribed capital of £6,000. Mr. Watson Smith registered the plaintiff company for that purpose, but the stipulated capital was never subscribed, nor were any directors appointed, and my offer consequently lapsed so long ago as October 17, 1892.

On June 29, 1893, a new company was formed under

the title of the Lamina Accumulator (Elieson's British Patents) Syndicate, Limited, and the necessary capital subscribed. I have duly transferred my patent to the last-named company, of which the Earl of Galloway was and is still the chairman.

It is, therefore, the abortive company which brought the action against the Earl of Galloway in which judgment has been given in his favour.—Yours, etc.,

C. P. ELIESON.

Broad-street-avenue, November 22, 1893.

[The case referred to by Mr. Elieson was dealt with in our last issue, and the conclusion of it is reported in another column.—ED. *E. E.*]

OIL AS FUEL.

SIR,—In your notes, November 3rd, you have an article on "Oil as Fuel." I have found oil refuse answer very well, but cost is rather prohibitive, being about £4 per ton.

I have used common coal tar for upwards of 12 months, and have no coal on the premises. This can be burned without smoke at a cost of £1 per ton. I find two barrels (about 8s.) take the place of one ton of ordinary coal, 14s.—Yours, etc.,

SYDNEY CHEELD.

Waterside Ironworks, Chesham, Bucks., November 20th, 1893.

LOAD FACTORS OF ELECTRIC TRAMWAY PLANTS.

BY FRANK B. LEA.

The recent meeting of an American street railway convention was very notable for the absoluteness with which electrical topics held the field. For some time past, indeed, each annual assembly of this kind has witnessed a gradual dropping out of "horse" talk, and an increasing amount of discussion upon electric traction; and at present in America forage and fodder are almost without interest to the tramway man. Not the least important of the subjects dealt with at the meeting above noticed was the question of employing accumulators or storage batteries in the generating station for the purpose of evening-up the load, not only throughout the day, but also from one minute to another, and this question was very fully treated by Mr. C. O. Mailloux in a special report to the convention. It is not altogether the present writer's object to criticise this report, because it would have for English and American readers two very different values; some slight comment, however, is necessary in order to define the base upon which future investigations into this subject may be founded.

It should be remembered, in the first place, that storage batteries have, for central station work, obtained no position whatever of importance in the United States, whilst on this side the Atlantic they enter into the design of almost all continuous-current supply stations. Therefore, the greater part of Mr. Mailloux's report is taken up with details gathered from various sources concerning the reliability and powers in general of accumulators as an adjunct to central-station work—whether for light or power distribution being, for that matter, of no consequence. In England and on the Continent such a question has gone past the "is it possible" stage: we take it as an axiom that accumulators serve a useful purpose. Whether it be an economical one is another matter, to be discussed later on.

In the first section of his report, however, Mr. Mailloux—in sketching out the characteristics and requirements of an electric tramway generating station—gives an interesting summary or statement of the position, from which may be, I think, seen at once just how far the employment of accumulators to help the generating plant is at all justifiable or worthy of consideration. It must not, however, be forgotten that there are more ways of killing a cat than by choking it with butter, and there are conceivable sources of reserve power (other than storage batteries) from which occasional drafts may be taken for an overload on the generating plant. It is with a view to elucidating some details of such, and comparing them together, that this article is written.

Mr. Mailloux gives in his report some very interesting figures and diagrams to show the enormous variations that take place in the output of an electric tramway generating station; and differentiates in an excellent way between what he calls the "fluctuations," or momentary changes in the total power demanded on the line (due to cars starting or stopping, running up and down hill, etc.), and the "variations," or changes occurring at several periods during the day when the traffic upon the line is exceptionally heavy (due to more cars being run, or more passengers carried, or both combined).

These variations or changes are, of course, well known to every electrical engineer who takes an interest in traction work, and have received much attention in consequence. I do not, however, think that Mr. Mailloux has been very successful or happy in the choice of terms to express these changes in output, for "variations" and "fluctuations" have to all intents and purposes the same meaning to the average man. Since he himself speaks of these changes as "waves," I would suggest that this expression be kept solely for the fluctuations or momentary changes. The idea of the changes that occur at tolerably fixed periods in the day will then be very clearly conveyed by speaking of them as "tides."

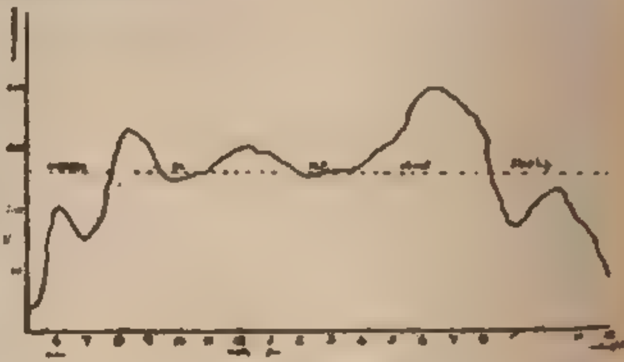


FIG. 1.—"Tides."

To show this contrast more clearly, the annexed diagrams may be of service. Fig. 1 represents a curve of "tides"—of course approximate only, and (it may be) exaggerated throughout. The total output spread over the working day is here shown in diagrammatic form, say, on a double line eight miles long, fairly level, with a total of 20 to 30 cars in operation. The "peaks," or points of maximum output, are, it will be seen, five in number, corresponding with the early morning cars for workmen; the eight o'clock service for clerks and business men; a similar one, but larger, at noon or one o'clock; the heaviest demand of all about 6 p.m., when work ceases for the day with the majority; and a final call after 10.30 p.m., when the theatres and places of amusement are closed.

FIG. 2.—"Waves."

Of course hardly any two lines will have similar load curves: the route followed, the districts served, and the class of passengers, will each and all exercise an important influence upon the total output of a generating station; but as a typical instance, the curve now given will serve to show the ups and downs of a very favourably situated line.

Taking the average output at 260 h.p., with a maximum of, say, 400 h.p., it will be seen that almost throughout the day a load factor is secured that would make an electric light station engineer green with envy. The greatest variations, indeed, are not more than from, say, half the mean load to less than double thereof, or from 50 per cent. below to 70 per cent. above.

The second diagram, Fig. 2, is a reproduction of a load

curve given by Mr. J. Greathead during a discussion upon Dr. Hopkinson's paper, entitled "Electrical Railways," read some months ago before the Institution of Civil Engineers. This curve is intended to illustrate the extent of "waves" in the output of an electric tramway station, as compared with the "tides" just mentioned. It is drawn up from instrument readings upon the City and South London Railway, with seven trains in operation upon the line, running on a headway of five minutes.

In less than five minutes, it will be seen the load curve crosses or touches the line of average horse power ten times, and varies from the 100-h.p. to the 300-h.p. mark within two minutes. Our electric light station engineer—who was green with envy a short time ago—will now feel a flush of satisfaction that his output does not vary quite so enormously as this, but comes on and off in pretty steady fashion, rising and falling by tens rather than hundreds of horse-power. Although, therefore, the tramway generating station has the advantage of four or five peaks in the day's load curve, as compared with only one, or perhaps two, in that of an electric lighting station, yet the "waves," or momentary fluctuations in the latter, are of little importance in comparison with those engendered by the constant stopping and starting of cars upon the tramway, or by their running in combination up or down grades at any instant.

The prime movers in a tramway station may be worked all day long at an average load of perhaps 60 per cent., but they must be excellently well governed, or must have very heavy flywheels, in order to prevent racing or a sudden pull-up when the load varies from zero to the maximum in the course of a minute or two.

It is worth remembering, moreover, that the instance given of "waves" does not represent by any means the type of greatest variation: the City and South London Railway is a line having fixed stopping places, with the stations placed on the top of inclines each way (so that power may be saved at such points), and with trains keeping a regular schedule. On an ordinary street tramway, the stops are, as a rule, quite arbitrary, the grades must be taken as they come—perhaps altogether in one section of the line—and the state of general traffic may render it difficult to prevent cars from bunching, two or three following one another in close order.

(To be continued.)

FITZGERALD'S IMPROVED LITHANODE AND SPONGY-LEAD PLATES.

Every voltaic battery—primary or secondary—is made up of a positive and a negative element immersed in an electrolyte or "exciting fluid." The positive element is usually zinc; but spongy lead, though it does not generate so high an electromotive force, is more convenient for long-continued use. For many years the impression prevailed that the positive element—the one consumed or oxidised when the battery is worked—was practically of greater importance than the negative. The contrary is now recognised as being the fact; the main point is to obtain a negative element that will not "polarise"—that is, become coated with hydrogen by electro-deposition. To obviate the effect of polarisation, the negative plate, if of carbon or platinum, is immersed in a powerful oxidant, such as nitric or chromic acid, or is surrounded by a solid oxidant such as binoxide of manganese. There is one plate, and one only, that does not require to be associated with an oxidant, since it is in itself (being almost wholly composed of peroxide of lead in a highly conductive form) the most powerful solid oxidant known, parting with its oxygen (to oxidise hydrogen) when "discharged," and absorbing it again when "charged," without ever becoming consumed or deteriorated when properly used. This negative element *par excellence* is *lithanode*.

Speaking of this material, a most trustworthy authority, Mr. J. T. Sprague, says: "Lithanode is a solid form of lead peroxide, and is the most practically useful form of the material." "Lithanode makes an excellent plate in secondary batteries, and is more especially adapted for small portable cells, where it is close upon perfection. It would be so for large cells also if the connection to it could be made of lower resistance." (This desideratum, it may be stated, has now been obtained.)

Mr. W. H. Preece, F.R.S., electrician to the Post Office, says: "I have had a cell (FitzGerald's lithanode) which gave a return as high as 5·7 ampere-hours per pound." (That is, per pound of *cell* complete.)

A well known medical man, writing to the *English Mechanic*, and of a correspondent of that journal, said: "I will show him lithanode cells that have been working a lamp intermittently for 18 months, and may also be able to give him some information about this (to me) invaluable product.—CHIRURGO, 7, Mornington-crescent, Hampstead-road."

With zinc and dilute sulphuric acid of sp. g. 1,160, lithanode gives an electromotive force of 2½ volts; so exactly, when the lithanode is in its normal condition, that the couple is sometimes used as a practical standard of electromotive force. With spongy lead and acid of sp. g. 1,182, lithanode gives two volts, which may be taken as the average E.M.F. of a lead secondary battery. Acid of this sp. g. contains 25 per cent. by weight of strong oil of vitriol (H_2SO_4).

The minimum capacity of fully-charged lithanode is one ampere-hour per ounce avoirdupois. That is to say, a ½lb. plate should yield a current of, say, half an ampere for 16 hours before its electromotive force (with spongy lead) falls from 2 to 1·8 volts. Lithanode (and other peroxide elements) should never be discharged beyond this point; indeed, it is better that the E.M.F. should not fall below 1·75 volts. The additional quantity that can be utilised by urging the discharge beyond this point is comparatively small; the current being no longer steady, and, when 1·8 volts has been reached, the fall of E.M.F. is rapid.

Practically, the capacity of spongy lead is taken as twice that of the lithanode plate. Theoretically, its capacity is much greater; but a large proportion of metallic lead must be left unconverted with sulphate in order to allow of the plate being recharged. The weight of the spongy-lead element need not, however, be more than half that of the lithanode plate.

The zinc-lithanode couple is most conveniently used as a primary battery—that is to say, when the couple is run down and the E.M.F. has commenced to fall rapidly, the electrolyte is thrown away and replaced by fresh dilute sulphuric acid of sp. g. not over 1,200, the zinc is reamalgamated, and a fresh lithanode plate is substituted for the old one, which may be put aside to be recharged when a sufficient weight of old plates has been collected to render it worth while to return them to the works. Lithanode is not affected by being left for a lengthened period in the acid; but zinc is, even when carefully amalgamated. Another objection to the use of the zinc-lithanode couple as a secondary battery is that you cannot practically recover all your zinc by recharging, so that sulphate of zinc accumulates in the electrolyte, and, by crystallising, gives rise to "creeping" and efflorescence. The lead-lithanode couple is entirely free from this inconvenience, and the spongy-lead element, as well as the lithanode, regains its original capacity.

The capacity for a given extent of surface of course varies with the thickness. Lithanode plates $\frac{3}{16}$in. thick have a capacity of about 40 ampere-hours per square foot of surface (taken on both sides of the plate); that is, about ·28 ampere-hour per square inch.

The improved lithanode plates most commonly made are ½lb. plates having about the following dimensions: 4¾in. by 3in. by $\frac{3}{16}$in. They can easily be cut by means of a fret or circular saw to any required smaller size, and sizes larger than the above can be obtained. The material is also readily drilled.

One of the most important points in connection with lithanode is the mode of making contact with it. One method, the only objection to which is that for many purposes it is too expensive, more especially for a *low-resistance* contact, is to apply to the surface of the material, by means of an ebonised screw and nut, a perforated disc of platinum foil, having a wire of the same metal in contact with it; a steady pressure being obtained by means of a

washer of caoutchouc. Plates with embedded contact strips of gilded lead, or gilded lead strips, to be clamped to the plate as above described, are now used.

When lithanode plates are mounted with an oxidisable metal, such as ordinary lead, one of the greatest advantages of the material is sacrificed—viz., the ability to retain its charge for any length of time when immersed in the electrolyte. The contact with an oxidisable metal reproduces, in fact, the great defect of all other lead accumulators, setting up a local action by which the active material and the support or contact mutually destroy each other.

ON THE EVOLUTION OF GAS DURING THE CHARGING OF ACCUMULATORS.*

BY C. BRUEGEMANN.

The author gives the results of about 20 experiments, in which the conditions governing the evolution of gas during the charging of accumulators were investigated. The cells used consisted of a positive plate, 8·5 centimetres long by 7·5 centimetres wide, suspended between two similar negative plates, at a distance of eight millimetres from it. The positive plate was coated on both sides with the active material, but the negative plates were coated only on the inner sides, so that the efficient area of both cathode and anode was practically the same—viz., 127 5 square centimetres. They were contained in glass vessels about half a litre capacity.

In order to collect the gases, each cell was closed with a cover of solid paraffin, through which passed two glass tubes. One, dipping into the acid served for filling the cell, and enabled the density of the liquid to be measured from time to time; the other opening into a funnel shaped cover, afforded a means of collecting the gas. The strength and E.M.F. of the current were measured by two Siemens torsion galvanometers, and at the commencement of an experiment the cell was completely filled with liquid. At suitable intervals samples of the gas were collected for analysis. Two characteristic experiments are given in detail. Cell No. 1 was in good working order, but in No. 2 there was local action.

—	Charge.				Total gas evolved in cubic centimetres.	Discharge.			
	Current strength in amperes.	Mean E.M.F. in volts.	Ampere hours.	Watt-hours.		Current strength in amperes.	Mean E.M.F. in volts.	Ampere hours.	Watt-hours.
No. 1	0 5	2·20	3·75	8·25	216·0	0·5	1·89	3 67	6·92
2	0 5	2·25	5 50	12 38	1,272 0	0 5	1 95	3·25	6·34

The experiment was made under the most favourable conditions for No. 2, the discharge being commenced directly the charging was completed, and yet the efficiency in ampere-hours was 38 8 per cent. less than that of No. 1, and in watt-hours 32·7 per cent. less.

The E.M.F. of No. 1 remained almost constant during the first two-thirds of the charging. It then rose, gradually at first, and afterwards rapidly, to a maximum of 2 71 volts But in the case of No. 2, in which there was local action, the E.M.F. rose steadily from the first, the rate only slightly increasing at about the same period of the charging when the rapid rise took place in No. 1. But the maximum attained in 20 hours was only 2 4 volts. There was a marked difference in the rate at which gas was given off, and also in its composition. With No. 1 oxygen appeared first 5½ hours after the current was turned on, and 40 minutes later hydrogen began to be evolved in rapidly-increasing quantity, the proportion 2 to 1 being reached after about an hour, at which time the E.M.F. was nearly at a maximum.

With No. 2, hydrogen was given off to a considerable extent from the very first, the oxygen only appearing after four hours and 40 minutes. At about the eighth hour oxygen was being evolved in the proportion of 14 to 16 of hydrogen. After this it decreased in amount, and at the eleventh hour the proportions were nearly normal. The author considers that the charging should be stopped when the E.M.F. begins to rise rapidly, in order to avoid the loss of energy, corresponding to the evolution of gas which then takes place. Within certain limits the strength of the charging current does not appear to affect the results. The same total volume of gas, having the same average composition, was given off when currents varying from 0·3 to 0·8 ampere were employed. Experiments were made as to the waste of energy from local action in a charged accumulator. During the first four hours seven cubic centimetres of hydrogen were given off per hour, but by the eighth day the amount had fallen to 1·3 cubic centimetre. It would appear, therefore, that the rate of loss is not constant, as had been supposed. The author points out the great importance of using pure acid and perfectly clean water for filling the cells.

* *Foreign Abstracts*, Institution of Civil Engineers.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE V.

(Continued from page 467.)

If the air is compressed isothermally, as it very nearly is in modern compound compressors, then the question arises, how much work is obtained in the compressed-air motor? If the air is used non expansively, as in the smaller motors used in Paris, and in much compressed-air plant, used for rock drilling and similar purposes, the work done in the motor is simply the admission work, $P_1 V_1$, less the work of expulsion, $P_a V_1$, neglecting valve resistance and friction—that is, the work obtained is—

$$P_a V_a \left(1 - \frac{P_a}{P_1}\right).$$

The efficiency of combined motor and compressor is then—

$$\eta = \frac{1 - \frac{P_a}{P_1}}{\log_e \frac{P_1}{P_a}}$$

$P_1 =$	2	3	4	6	8	10 atmospheres
$\eta =$	0 72	0·61	0·54	0·46	0·42	0·39.

The efficiency diminishes rapidly with increase of initial pressure, and it is the use of bad and inefficient air plants of this kind which has given compressed air a bad name and made engineers hesitate to adopt high working pressures. To obtain good results, the air must be used expansively. Suppose the air expands in the motor without gain or loss of heat, a realisable condition, and let clearance and loss in mains be neglected, as well as friction, then the indicator diagram of the motor will be A B F M, the expansion curve being an adiabatic, F M, and the air cooling during expansion. The efficiency of the whole arrangement will be the ratio of the area A B F M to the area A B F D. It is easy to show that that efficiency is given by the equation—

$$\eta = \frac{95{,}600 \left[1 - \left(\frac{P_a}{P_1}\right)^{0·29}\right]}{27{,}710 \; \log_e \frac{P_1}{P_a}}$$

RESULTANT EFFICIENCY OF COMPRESSOR AND MOTOR.

Working pressure pounds per square inch. By gauge.	Absolute P_1	$\frac{P_1}{P_a}$	η
14·7	29·4	2	·906
44·1	58 8	4	·824
73·5	88·2	6	·780
102 9	117·6	8	·752

Practically, it is necessary to use pressures of 45lb per square inch at least, that the apparatus may not be too cumbrous. The calculation shows that when using the air properly, much higher working pressures may be adopted without sensible loss of efficiency.

Various means have been adopted to cool the air during compression. Sommeiller adopted water pistons, which are very effective, and in the early compressors at Mont Cenis very good results were obtained But there are practical objections to water-piston compressors; they must be worked slowly, and are costly and cumbrous. In the St. Gothard compressors the much less

* Howard Lectures delivered before the Society of Arts

effective arrangement of a cold-water jacket was adopted; but air does not part with heat readily to a metal cylinder, and the cooling surface of the cylinder is too small to permit much of the heat to be abstracted; hence, later, a method proposed by Prof. Colladon of injecting a water spray into the cylinder was adopted, and by this means a much more cooling action was obtained. To some extent, however, the cooling action of the spray is deceptive: the cooling takes place partly in the passages of discharge, and the compression curve is not lowered so much as it should be.

Compound Compressors.—The author is not aware when compound compressors were first used. They were, it is believed,

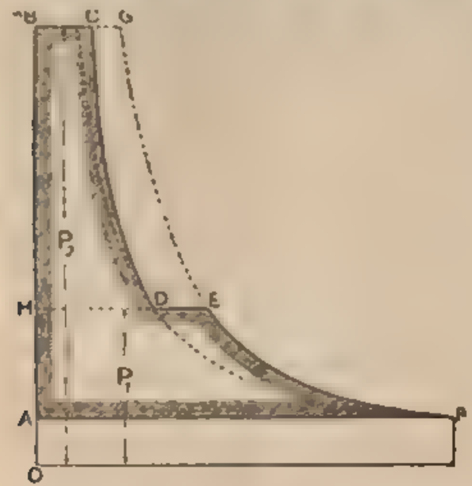


FIG. 25.

used by Mekarski, and, possibly, by others, in cases where a high pressure was required, at a comparatively early date. Mr. Northcott made a two stage compressor, with intermediate cooling arrangements in 1878. The Norwalk Company, in America, constructed compound compressors for mines in 1880, apparently more with a view to equalise the effort during the stroke than to obtain higher efficiency. In 1881, however, they introduced an inter-cooler between the high and low pressure compression cylinders. This consisted of a reservoir with thin brass pipes through which cold water circulated. The effect of this intermediate cooling is very important in reducing the heating loss. The compound diagram is shown in Fig. 25. Air is compressed to P_1 in the low pressure cylinder. Then, in passing through the inter-cooler, it shrinks in volume from H E to H D. It is then further compressed to P_2 in the high pressure cylinder. The work saved by the intermediate cooling is the area E D C G. The adoption of these compound compressors is important, because it removes the chief objection to the use of high working pressures in a system of compressed air transmission.

Compressor Valves.—In most compressors simple fluid-moved valves are employed. The objection to them is that they create some prejudicial resistance involving waste of work, and they prevent the compressor being worked at high speed. In many compressors mechanically moved valves are employed, for instance slide or Corliss valves. The compressor can then be run faster, but the resistance at the valves is still serious. Prof. Riedler uses valves which open automatically and are closed mechanically, and these no doubt obviate the objections to ordinary valves. Fig. 26 shows one form. This is a flap valve so set that it tends to open. It is closed by a lever worked by a cam.

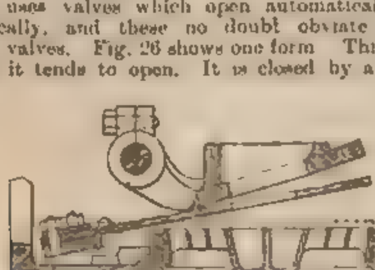


FIG. 26.

Mr. Pearsall's Hydraulic Air-Compressing Engine.—Mr. H. D. Pearsall, apparently incited by a study of the early hydraulic ram compressors of Sommeiller, has designed a very interesting hydraulic compressing engine, in which air is compressed directly by a water column, without cylinders and pistons.

Fig. 27 shows this engine in section. A is the supply-pipe, by which water, with the energy due to its descent from a higher level, flows into the apparatus. C is a large cylinder valve which, when open, allows the water to flow out into the tail-race, and, when shut, forces the column of water to rise into the compression chamber, M. The column of water in the supply pipe is allowed to acquire velocity by outflow into the tail race. The valve, C, is then mechanically closed, and the descending column expends its energy in compressing the air in the chamber, M, and discharging it into the receiver, E. The cylinder valve, C, is actuated by a small air motor. The chamber, M, empties the water through the cylinder valve, C, and fills with air through the air valve, H, which is controlled by a float. The adjustment is such that the column of water can be made to come to rest at the instant when it reaches the delivery plate.

Mr. Pearsall claims that very high velocities of flow can be permitted without danger or loss of efficiency. Some experiments made with a small apparatus gave an efficiency of 80 per cent.

The engine is simple, and there seems no reason why it should not have a high efficiency. But till experiments have been made on a larger scale, it is impossible to say what the delivering capacity of the machine in a given time is. Till that is determined it is uncertain whether it would be more costly or less costly than ordinary compressors worked by turbines.

Losses in Transmission.—The frictional resistances in a pipe conveying fluid are proportional to the density of the fluid; consequently, at equal velocities the frictional resistance of air is enormously less than that of water. Conversely, air may be transmitted in air mains without serious fall of pressure, at 10 or 20 times the velocity practicable with water in water-mains. Air, at 90lb. per square inch pressure, is about 115 times lighter than water, and the frictional resistance, at equal velocities, is less than 1 per cent. of that of water. In air mains there is nothing analogous to the hydraulic shock, due to changes of velocity, which, as well as the friction, leads to a limitation of the velocity of water in mains to 3ft. per second, in most cases, or to 6ft. per second in some cases.

In air mains, velocities of 30ft. to 50ft. per second are allowed, without serious frictional loss. In consequence of this high velocity, large amounts of power can be transmitted by air at moderate pressures, and in mains of moderate dimensions.

The hydraulic mains of the London Hydraulic Power Company are 6in. in diameter, the pressure is 750lb. per square inch, and the velocity 3ft. per second. That corresponds to the transmission of 90 effective horse-power by each main. But air at 45lb. pressure per square inch, with a velocity of 50ft. per second, would transmit 150 effective horse-power in a main of the same size. The largest high pressure hydraulic mains are 7in. in diameter. But there is hardly any limit to the size of air mains. The new Paris main from the Quai de la Gare to the Place de la Concorde—seven kilometres in length—with air at 90lb. pressure per square inch, transmits 6,000 h.p.

In the older Paris mains which were carried through the sewers, and which had an exceptionally large number of bends, draining-boxes, and other sources of resistance, the frictional resistance, with a velocity of 25ft. to 30ft. per second, only amounted to 2lb. per square inch per mile of main. It would be only in very long distance transmissions that the fall of pressure in the mains would be large enough to sensibly affect the efficiency of the system.

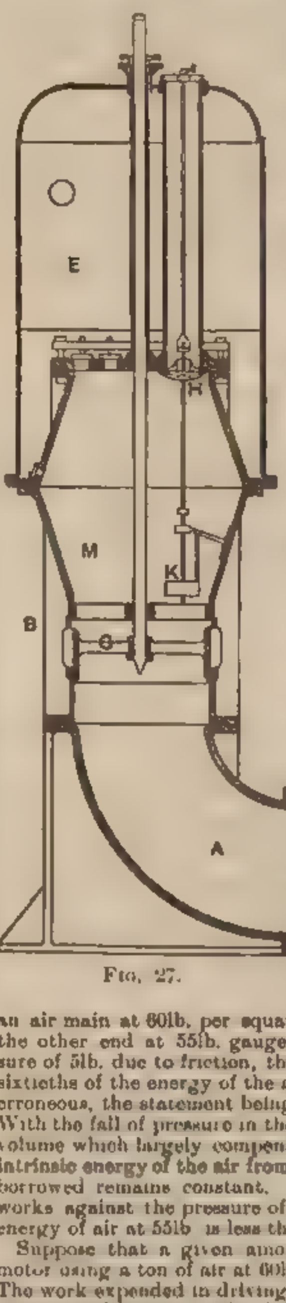


FIG. 27.

As to the precise way in which a fall of pressure in the mains influences the efficiency, there is a word to be said. If air enters an air main at 60lb. per square inch gauge pressure, and reaches the other end at 55lb. gauge pressure, there being a fall of pressure of 5lb. due to friction, then it is commonly stated that five-sixtieths of the energy of the air is wasted. But this is altogether erroneous, the statement being based on a false hydraulic analogy. With the fall of pressure in the case of air, there is an expansion of volume which largely compensates for the loss of pressure. The intrinsic energy of the air from which the work of the air motor is borrowed remains constant. It is only because the air motor works against the pressure of the atmosphere that the available energy of air at 55lb. is less than that of air at 60lb. pressure.

Suppose that a given amount of work can be done by an air motor using a ton of air at 60lb. gauge pressure, or 75lb. absolute. The work expended in driving this motor by a compressor adjacent to it would be the work of compressing one ton of air to 75lb. absolute pressure. Now let the compressor be removed to a couple of miles distance, and the air supplied to the motor through a main in which there is a fall of pressure of 5lb. per square inch. To do the same work as before, all that is necessary is that a ton of air should be compressed to 80lb. absolute pressure. The difference between the work of compressing a ton of air to 80lb. and to 75lb. absolute pressure is the loss of work arising out of the friction of the main, and this amounts with fairly good compressors to about 3 per cent.

In short distance transmissions the loss of pressure in the mains is so insignificant that it may be neglected. In long distance transmissions an accurate estimate of the frictional loss is necessary. The author believes that he has shown, using data derived from careful experiments on 20 miles of main in Paris, that long distance transmission of power by compressed air is perfectly practicable. It is possible, with compressors driven by engines working to

10,000 i.h.p. to transmit the air, in a main of not unusual size, a distance of 20 miles, and to obtain in motors worked by the transmitted compressed air from 4,000 i.h.p. to 5,000 i.h.p. if the air is used cold, or 6,000 i.h.p. to 7,000 i.h.p. if the air is reheated before use.

The Air Motors.—The air motor is essentially a reversed compressor, but it is free from the heating difficulty. The air cools in expanding, and, in some cases, this causes trouble from the production of ice in the valve passages. The rounding of the edges of the ports so that the ice can be pushed away diminishes the trouble, and heating the air before use entirely obviates it.

Some special rotary motors of small size are used in Paris, but they are not economical, and most of the motors are simply non-condensing steam engines adapted to use air. Probably the greatest cause of loss in air motors has been leakage, especially piston leakage. In a steam engine the condensation on the cylinder wall helps to make the piston tight. In an air motor the cylinder surface is dry, except so far as lubricant is supplied.

Cost of Working with Compressed Air.—Air motors can be obtained, erected complete, for two thirds of the cost of a steam engine and boiler. In the very imperfect small rotary motors in Paris, the consumption of air compressed to five atmospheres (75lb. per square inch) is 750 to 850 cubic feet per effective horse power hour. Old steam engines converted to air motors use 450 cubic feet per effective horse power hour. Now, the new compound air compressors at Paris compress a cubic metre of air to a higher pressure than this for 0.4 centime. If 0.75 centime per cubic metre is allowed to cover interest on plant, as well as cost of compression, this corresponds to 1d. per 880 cubic feet of compressed air. Hence the cost of working with compressed air amounts to 1d. per effective horse power hour with inefficient rotary motors, and about ½d. per effective horse power hour with the converted steam engines. In the latter case the cost corresponds to about £6. 5s. per effective horse power for a year of 3,000 working hours. Better results than these will be obtained when air motors are studied as carefully as air compressors.

(To be continued.)

BOARD OF TRADE AND TRACTION.

Draft Regulations made by the Board of Trade under the provisions of the —— Tramways Act, for regulating the employment of insulated returns, or of uninsulated metallic returns of low resistance; for preventing fusion or injurious electrolytic action of or on gas or water pipes or other metallic pipes, structures or substances; and for minimising as far as is reasonably practicable injurious interference with the electric wires, lines, and apparatus of parties other than the company, and the currents therein, whether such lines do or do not use the earth as a return.

Definitions.—In the following regulations:

The expression "energy" means electrical energy.

The expression "generator" means the dynamo or dynamos or other electrical apparatus used for the generation of energy.

The expression "motor" means any electric motor carried on a car and used for the conversion of energy.

The expression "pipe" means any gas or water pipe or other metallic pipe or structure or substance.

The expression "wire" means any wire or apparatus used for telegraphic, telephonic, electrical signalling, or other similar purposes.

The expression "current" means an electric current exceeding one thousandth part of one ampere.

The expression "the company" has the same meaning as in the Tramways Act.

Regulations.

1. Any dynamo used as a generator shall be of such pattern and construction as to be capable of producing a steady continuous current.*

2. One of the two conductors used for transmitting energy from the generator to the motors shall be in every case insulated throughout its length, and is hereinafter referred to as the "line"; the other may be insulated throughout, or may be uninsulated in such parts and to such extent as is provided in the following regulations, and is hereinafter referred to as the "return."

3. Where any rails on which cars run or any conductors laid between such rails form any part of a return, such part may be uninsulated. All other returns or parts of a return shall be insulated.

4. When any uninsulated conductor laid between the rails forms any part of a return, it shall be electrically connected to the rails at distances apart not exceeding 100ft. by means of copper strips having a sectional area of at least one-sixteenth of a square inch, or by other means of equal conductivity.

5. When any part of a return is uninsulated it shall be connected with the negative terminal of the generator, and in such case the negative terminal of the generator shall also be directly connected, through the current indicator hereinafter mentioned, to two separate earth connections which shall be placed not less than 20 yards apart. Provided that in place of such two earth connections the company may make one connection to a main for water supply of not less than 4in. internal diameter, with the consent of the owner thereof. Such earth connections shall be constructed, laid, and maintained, so as to secure contact with the general mass of earth, and so that an E.M.F. not exceeding four volts shall suffice to produce a current of at least two amperes from one earth connection to the other through the earth, and a test shall be made at least once in every month to ascertain whether this requirement is complied with. Where any portion of either earth connection is placed within 6ft. of any pipe, and the company are unable to obtain permission to metallically connect it with the earth connection, they shall provide, by means of non-conducting screen, that no current can pass between the pipe and the earth connection without traversing at least 6ft. of earth.

6. When the return is partly or entirely uninsulated, the company shall in the construction and maintenance of the tramway (a) separate the uninsulated return from the general mass of earth, and from any pipe in the vicinity; (b) connect together the several lengths of the rails; (c) adopt means for reducing the difference produced by the current between the potential of the uninsulated return at any one point and the potential of the uninsulated return at any other point; and (d) maintain the efficiency of the earth connections specified in the preceding regulations, so as to fulfil the following conditions, viz.: (i.) That the current passing from the earth connections to the generator shall not at any time exceed 10 amperes. (ii.) That if at any time and at any place a test be made by connecting a galvanometer or other current indicator to the uninsulated return and to any pipe in the vicinity, the direction of the current, if any, shall be from the return to the pipe and not *vice versâ*. (iii.) That under the conditions specified in (ii.) it shall always be possible to reverse the direction of the current by interposing a battery of three Leclanché cells connected in series.

In order to provide a continuous indication that the condition (i.) is complied with, the company shall place in a conspicuous position a suitable, properly connected, and correctly marked current indicator, and shall keep it connected during the whole time that the line is charged. The owner of any pipe may require the company to permit him to ascertain by test that the conditions (ii.) and (iii.) are complied with as regards his pipe.

7. When the return is partly or entirely uninsulated its electrical resistance shall be tested by the company at least once in every three months. If at any such testing it appears that the resistance has increased by more than 15 per cent. above the value recorded at the time the tramway was opened, the company shall take immediate steps to reduce the resistance to the said recorded value.

8. Every electrical connection with any pipe shall be so arranged as to admit of easy inspection, and shall be tested by the company at least once in every three months.

9. Every line and every insulated return or part of a return shall be constructed in sections not exceeding one half of a mile in length, and means shall be provided for isolating each such section for purposes of testing.

10. The insulation of the line and of the return when insulated, and of all feeders and other conductors shall be so maintained that the leakage current shall not exceed one hundredth of an ampere per mile of tramway. The leakage current shall be ascertained daily before or after the hours of running when the line is fully charged. If at any time it should be found that the leakage current exceeds one tenth of an ampere per mile of tramway, the running of the cars shall be stopped until the leak has been localised and removed.

11. The insulation resistance of all lines, insulated returns, feeders, or other conductors, laid below the surface of the ground, shall not be permitted to fall below the equivalent of 10 meghoms for a length of one mile. A test of the insulation resistance of each part of the circuit shall be made at least once in each month.

12. Where in any case in any part of the tramway the line is erected overhead and the return is laid on or under the ground, and where any wires have been erected or laid before the construction of the tramway in the same or nearly the same direction as such part of the tramway, the company shall if required so to do by the owners of such wires or any of them, permit such owners to insert and maintain in the company's line one or more induction coils or other apparatus for the purpose of preventing disturbance by electric induction.

13. Any insulated return shall be placed parallel to and at a distance not exceeding 3ft. from the line when the line and return are both erected overhead, or 18in. when they are both laid underground.

14. In the disposition, connections, and working of feeders the company shall avoid injurious interference with any existing wires.

15. The company shall so construct and maintain their system as to secure good contact been the motors and the line and return respectively, and they shall not allow sparking to occur at the rubbing or rolling contacts in any part.

16. In working the cars the current shall be varied as required by means of a rheostat containing at least 20 sections, or by some other equally efficient method of gradually varying resistance.

17. In the construction and use of their generator and motors the company shall take all reasonable precautions to prevent the occurrence of undue sparking.

18. Where the line or return or both are laid in a conduit, the following conditions shall be complied with in the construction and maintenance of such conduit: (a) The conduit shall be so constructed as to admit of easy inspection of, and access to, the conductors contained therein and of all insulators and supports. (b) It shall be so constructed as to be readily cleared of accumulation of dust or other *debris*, and no such accumulation shall be permitted to remain. (c) It shall be laid to such falls and so connected to sumps or other means of drainage as to automatically

* The Board of Trade will be prepared to consider the issue of regulations for the use of alternating currents for electrical traction on application.

clear itself of water without danger of the water at any time reaching the level of the conductors. (*d*) If the conduit is formed of metal, all separate lengths shall be so jointed as to secure metallic continuity for the passage of electric currents, and where the rails are used to form any part of the return they shall be electrically connected to the conduit by means of copper strips having a sectional area of at least one-sixteenth of a square inch, or other means of equal conductivity, at distances apart not exceeding 100ft. Where the return is wholly insulated and contained within the conduit, the latter shall be connected to earth at the generating station through a high-resistance galvanometer suitable for the indication of any contact or partial contact of either the line or the return with the conduit. (*e*) If the conduit is formed of any non-metallic material not being of high insulating quality and impervious to moisture throughout, and is placed within 6ft. of any pipe, a non-conducting screen shall be interposed between the conduit and the pipe, of such material and dimensions as shall provide that no current can pass between them without traversing at least 6ft. of earth.

19. The company shall, so far as may be applicable to their system of working, keep records as specified below. These records shall, if and when required, be forwarded for the information of the Board of Trade.

Daily Records.—Number of cars running. Maximum working current. Maximum working pressure. Maximum current from the earth connections (*vide* Regulation 6 (i.)). Leakage current (*vide* Regulation 10).

Monthly Records. — Condition of earth connections (*vide* Regulation 5). Insulation resistance of different conductors (*vide* Regulation 11).

Quarterly Records.—Resistance of return (*vide* Regulation 7). Conductance of joints to pipes (*vide* Regulation 8).

Occasional Records.—Any tests made under provisions of Regulation 6 (ii. and iii.); localisation and removal of leakage, stating time occupied; particulars of any abnormal occurrence affecting the electric working of the tramway.

LOCOMOTION IN LONDON.

The following is a copy of a draft report prepared by Mr. W. Saunders for consideration by the Public Health and Housing Committee of the London County Council:

In accordance with the resolution of the Council of October 3, we have considered "the best means of obtaining information on the question of locomotion in London, including railways, tramways, omnibuses, and steamboats." We recognise that the subject is one of supreme importance from sanitary, social, and commercial standpoints. The population and area of the Metropolis being far beyond that of any other city, the distances to be covered are so great that travelling facilities have become a necessity for all classes. The large increase of value which has taken place in business premises makes it essential to provide house accommodation on cheaper land than is available in business localities. Moreover, from the great extension of industrial establishments, it has become physically impossible to provide house accommodation in the neighbourhood of their employment for such multitudes as are now engaged in the industries of London.

From a sanitary point of view the question is equally pressing. There is no known method by which population can be crowded as in London without danger to health and loss of life. Additional air space is essential which can only be given by extending the area of occupation. This is impossible within the business limits of the Metropolis; room must be sought outside those limits and improved means of locomotion provided. The serious results of overcrowding in London will be seen from the following statement showing the

Death-Rates in Five Groups of London Sanitary Districts, Arranged in Order of Density of Population.

	Mean death-rate, 1885-1891.
Districts with density of under 40 persons per acre	15·27
" " 40 to 80 persons per acre	18·04
" " 80 to 120 " "	19·24
" " 120 to 160 " "	22·60
" " over 160 " "	23·88
County of London, 57 persons per acre	19·90

With the necessity for dispersion of the population have come the means by which full facilities for transport can be obtained. Passenger railways with an equal carrying capacity to that of the Metropolitan and District Railway, can now be constructed at one-third of their cost. Electric transit, which has been proved to be efficient and economical, does away with the injurious atmospheric condition hitherto attached to tunnel transit, and thus a serious objection to underground railways is removed.

At the request of the London County Council, Parliament has, in recent Bills for underground railways, removed some of the restrictions by which they were limited to land under roadways. They can now be constructed under private property, and with these improved conditions electric railways can be constructed with less cost and with greater efficiency than was the case with the City and South London Railway. The great and costly disturbance of property by the construction of surface railways, or railways in shallow tunnels, is now avoided by deep tunnels constructed, where necessary, under air pressure. By the use of a shield these tunnels can be driven through soft clay or wet gravel, so that the engineer has only to consider where a railway is wanted, and there, usually, it can be made.

In nearly all directions round London land suitable for building can be found, and much of the land is now of little value. To give effectual relief it will be necessary to drive railways through the city right into the country, so as to obtain access to cheap building land. The underground portion of these railways would be limited to the land already covered with buildings. The railway would be brought to the surface as soon as open ground is reached.

The subject of London railways has received of late years the careful consideration of the most able engineers and experienced railway managers. They appear to have arrived almost unanimously at the conclusion that the establishment of a central railway station, which is found so convenient in smaller cities, is quite impracticable for London, and they are generally agreed that existing terminal stations cannot be brought farther towards the centre of the Metropolis. Not centralisation but distribution is required, and a system of passenger railways for distributing travellers over the whole of London would be welcomed by existing railway companies.

The Joint Select Committee of Lords and Commons appointed last year to consider the electric and cable railway schemes then before Parliament, report respecting these railways that "they are required to relieve the overgrown passenger traffic along the chief thoroughfares, to provide for the natural expansion of London, and to check the congestion of our metropolitan population by facilitating cheap communication outwards to a circumference which tends constantly to recede. More such lines of communication are required with existing suburbs, and there is a growing need of their extension into the country, in order to meet the increasing necessity for the removal of portions of the population to a greater distance."

Mr. Scotter, the general manager of the London and South-Western Railway, in giving evidence before the Joint Committee of Lords and Commons on Electric and Cable Railway, said: "I have come to this conclusion, that the making of the City and South London Railway has altered the whole state of this question. I believe this is only an instalment of many schemes that will be projected in future, especially as the problem has been solved of making an underground railway at about one-third of the cost of the old Metropolitan and District Railways. Something will have to be done to relieve the congested traffic of the streets, and I do not see anything better than these light underground railways, made at a cost of, say, £250,000 per mile, instead of £750,000, which was the cost of the other railways."

It is obvious that the Council need not incur the cost and delay which would arise from considering new systems of locomotion; all that is necessary is to discover the best application of well-known and existing methods. The details for forming a judgment are already provided, and therefore the proposed enquiry need not be costly or prolonged.

The present means of railway locomotion are wholly inadequate, but wherever they are provided at a moderate cost for short passenger traffic those means are largely used. This can be seen by the rush of passengers to and from Broad-street, Liverpool-street, Waterloo, and other stations. This short distance traffic, although in itself profitable, cannot be sufficiently provided for on through railways, which depend mainly on long-distance traffic. Special provision must therefore be made if the people of London are to be adequately accommodated.

It is important that means for locomotion should be provided at the lowest remunerative price. The chairman of the Great Eastern Railway has stated that the traffic between Enfield and Broad-street, at a charge of 2d. for the double journey of 22 miles, is profitable to the company. As this charge meets traffic cost, and pays its share of interest on capital, it may be hoped that a still lower rate, say 1d. on 20 miles, would be found sufficient to meet all expenses, after taking the increased value of land for the cost of construction.

As it is a proved and recognised fact that the construction of railways adds greatly to the value of land, and that the increased value might be made available for the purpose of meeting the cost of constructing railways, the proposed enquiry will probably show that passenger railways might be provided for London without being a burden on the ratepayer, and that the charge for travelling might be so small as to enable all classes to avail themselves of the accommodation. It is, however, obvious that these great advantages can only be secured by equitable arrangements which will secure to the public the increased value imparted to land by such public expenditure.

What occurred as a consequence of the free ferry at Woolwich should be considered in connection with travelling facilities. After this ferry was established, at the cost of the ratepayers, the Council purchased 11 acres of adjoining land for an open space, and for this land they had to pay an additional cost of at least £500 per acre because a free ferry had been established. It is therefore clearly essential that in any plans for affording facilities of transport the increased value of land created thereby should be appropriated to public purposes. The Council's valuer has been asked to give his opinion as to the increased value that would be imparted to land by the construction of a line as proposed through London, radiating 20 miles in each direction from the centre.

The difficulty in relying upon private enterprise arises from the fact that private companies are unable to obtain the increased value of land imparted by railways, which value may accrue to a public authority. This fact, with the great cost of promotion and parliamentary expenses, make it impossible for private enterprise to provide railway accommodation without imposing charges which would be incompatible with full development. It is clearly

desirable that the proposed railways should be laid out on a comprehensive plan, any portion of which might be undertaken, either immediately or later, with due regard to the final results of a complete system.

Omnibuses. The vast increase which has taken place in omnibus traffic shows that the business of omnibus companies is on the whole well conducted, but existing conditions present this anomaly, that while omnibuses, of which there are 2,305 running in London, have free use of public roads, and thus impose heavy burdens on the ratepayer they are not subjected to regulations which are enforced upon other means of transit. Thus we have pirate omnibuses making charges by which the public are entrapped. In the suburbs of London fares are so high that omnibuses wear out the public roads while rendering very little public service. These are matters which clearly require investigation.

Steamboats. The service of steamboats on the Thames is infrequent, costly, and quite unworthy of the provision which has been made for it by the erection of piers in connection with the embankment. Boats at half the present fares and twice as frequent would be a valuable addition to the present means of transport.

Conclusions.—Railways must, for the most part, be relied upon for conveying passengers a sufficient distance to secure proper distribution of population. It is only by railways that passengers can be carried in sufficient numbers and within a reasonable time. The average speed on passenger railways is 2½ times that of tram cars or omnibuses, and the actual cost of transit is much less. Therefore, our chief reliance for relieving London from overcrowding must be upon railways. Tramcars, omnibuses, and steamboats are, however, essential parts of a general system of locomotion, and should be considered in connection with railways. The improvements which have recently been made to the construction of city railways open up opportunities which should be utilised on a general system for passenger railways throughout the Metropolis and adjacent country districts. This work can now be done with very little displacement of property, with a small expenditure for land purchase, and with a beneficial expenditure on labour and materials which will create value and afford useful employment. Recommendations:

1. As railways and tramways involve engineering consideration, we recommend that the subject should be referred to Mr. ——, an experienced engineer at a fee not exceeding £ ——, to report: (*a*) As to the best routes for passenger railways and tramways to provide means of communication between all parts of the Metropolis and adequate connection with surrounding country districts, having due regard to population and convenience of construction. (*b*) As to the cost of constructing such railways and tramways, taking into account the latest improvements. (*c*) The cost of working such railways and tramways and the fares which should be charged. (*d*) In conference with the valuer of the Council to report as to the cost of land at various points suitable for building, and the effect of such railways upon the value of land, both in London and in the country.

2. Omnibuses and steamboats should, we think, be made the subject of an enquiry by an able accountant or inspector, in order to ascertain existing routes and fares, and to suggest such regulations as may be desirable for the consideration of the Council.

3. These reports could be obtained for the sum of £500, which amount should be appropriated to this enquiry from the £1,000 which the Council, under the Act of last session, are authorised to expend at their discretion.

This report, together with the recommendations contained therein, has been adopted by the Council.

LEGAL INTELLIGENCE.

ELIESON ACCUMULATOR COMPANY v. THE EARL OF GALLOWAY.

The hearing of this case, which was referred to in our last issue, was resumed and concluded on Wednesday before Mr. Justice Kennedy, without a jury, in the Queen's Bench Division. It will be remembered that this was a claim for £400 for money payable on the allotment of shares to the defendant in the plaintiff company.

Mr. Clavell Salter appeared for the plaintiff company; and Mr. Lockwood, Q.C., and Mr. Pollard for the defendant.

The plaintiffs' case was that the defendant applied for 2,000 £1 shares in the company, and paid £100 as a deposit of 1s. a share on application. The shares were duly allotted, and £400, now sued for, then became due.

Mr. Watson Smith, the promoter of the company, was called and examined and cross-examined at some length as to the circumstances of the case.

Mr. Lockwood, for the defence, contended that in August, 1892, the defendant handed to Mr. Smith £50 to be held by him as deposit for shares in a prospective company, but only to be applied for, by Mr. Smith as the defendant's agent, according to a prospectus which stated that a contract had been entered into for the purchase of patents for £6,000 and if certain conditions were fulfilled. Among those conditions was one that *bonâ fide* applications from persons other than Lord Galloway should be received for shares to the extent of £2,000. On October 13, 1892, the defendant wrote saying he would not proceed unless his conditions were fulfilled, and appointed a meeting with Lord Sackville Cecil for the next day. On the morning of the 14th, and before that meeting was held, Mr. Smith now alleged that he had held a meeting of the company in his office and proceeded to registration and allotment. That allotment could not be relied on as a *bonâ fide* allotment. As a matter of fact, the patents never were acquired, and the company was really no other than Mr. Smith; and whatever instructions were given by the defendant to Mr. Smith, they were revoked on October 13 or October 14.

Mr. Salter submitted that after Mr. Smith had made an application the authority could not be withdrawn. Even if the authority was withdrawn, the withdrawal was not communicated to the company.

Mr. Justice Kennedy, on Wednesday morning, delivered judgment, and while stating the facts, said the plaintiff company was apparently formed for the working of an English patent which was said to be the best accumulator for electrical purposes and especially for the locomotion of tramcars. In July, 1892, the defendant seemed to have been easily drawn into the hope that it would be a success, and exhibited a trustfulness which must have been pleasing to the promoter. The defendant somehow got on the register of the plaintiff company, and he did authorise Mr. Watson Smith to apply on his behalf for shares if there was then a genuine company which was in a position to do what it was formed to do and carry out its purposes as represented. Now Watson Smith pushed the concern and was the foundation of the company, and then Mr. Elieson was added to him; and this was confirmed by Mr. Pallas, who also had a share in the company. By September 24, £100 had been paid to Mr. Smith by Lord Galloway. Was it a payment to himself as a promoter or for the purposes of the company? Perhaps both, but it passed into his private banking account. At the interview of October 13 with the defendant, the chairman, Mr. Watson Smith, stated that the company was registered; but there was a conflict as to what took place afterwards, and it was left in some doubt by the defendant, and he could not find that then the defendant stated that he meant to withdraw unless the conditions he required were fulfilled. But he regretted he could not trust the version of the plaintiffs' witness in this and in other matters. He did not believe that the defendant pressed for allotment, and he denied it positively. This was borne out by what took place at the meeting at Lord Sackville Cecil's on the following day, and a letter was written on October 17 by Mr. Drew, Lord Galloway's agent, corroborating this view, that W. Smith was not to exercise his authority to apply for shares till certain conditions were fulfilled, and that he waited to see if a company had been registered. The allotment was alleged to have taken place on the 14th, and the minute book was said to have been written up a day or two later, but the secretary ought to have immediately notified the fact to the allottees. But no such notice was given till October 20, after Mr. Drew's letter of the 17th to the secretary. The plaintiffs' counsel had treated the case with equal frankness and ability and it seemed that the defendant told W. Smith that he did not mean to have any interest in the company unless his conditions were fulfilled. But Watson Smith was silent on any allotment, and he could not trust that witness when in conflict with two or three credible witnesses, especially after the matter of a statement that he had paid a sum of £300 on account of Lord Galloway "at some inconvenience" when no such sum turned out to have been paid. Watson Smith attended at the interview at Lord Sackville Cecil's as chairman of the company, and said nothing of the allotment to the defendant, which he thought honour and good faith would have required. Why could he not have said, "Why, you are a shareholder already, made so yesterday on my application?" Any application for shares according to the terms of the agency could only be made if the company fulfilled its objects. Was it, then, a full going concern? He thought not. A company had been registered by Elieson's wish and advice, but there was nothing effectual: it had not been confirmed by Pallas: nothing enabling the company to call on Elieson to sell his patent to them. They went on probably with the object of getting more money from Lord Galloway, and they were not in a position honestly to say that they had carried out the provisions of the prospectus, though he assumed that they could call on Elieson for the fulfilment of his agreement. The company kept no bank book, and had no banking account: except two gentlemen, all the members were the nominees of Watson Smith. Was this, then, a company in which the defendant authorised him to apply for shares? He thought not. Mr. Elieson did not subscribe, and the company had nothing, no right to any contract, and had not the necessary essentials of a company. There was then, a withdrawal before the acceptance of the shares notified by the defendant to the plaintiffs before the posting of the secretary's letter. It was said that the notice of withdrawal of October 14 was given to W. Smith and not the company; but he thought that gentleman attended the meeting as a director or agent for the company. Mr. Dawes said he then represented the company, and that they discussed the terms on which Lord Galloway would become interested in the concern. He found there was a notice to the company that the defendant would not take an interest therein except on certain conditions, which were not carried out. But if there was an authority, then there was sufficient evidence of a revocation. The case cited by the plaintiffs' counsel in 7 Chan. App., 161, was no doubt binding on a court of first instance. But in every case due regard must be paid to the character of the director, notice to whom was there held not to affect the company. There would be judgment for the defendant on the claim, with costs, and an order that his name be expunged from the register. But as to his counter claim for the two sums of £50, as these had passed into Watson Smith's private account and had never come into the possession of the plaintiffs, there would be judgment for them as to that, with costs of that issue.

COMPANIES' MEETINGS.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.

Mr. W. S. Andrews presided over the ordinary general meeting of the Western and Brazilian Telegraph Company, Limited, held last week at Winchester House, E.C.

In moving the adoption of the report, the **Chairman** said that the total earnings for the half year amounted to £79,373, as against £84,021 in the corresponding half year. The working expenses amounted to £43,424, as against £39,140, or an increase of £4,283, which was principally due to the cost of the extra staff and arrangements required to work efficiently the duplicated and duplexed line. The object of the loop cables was to avoid interruptions and so keep the traffic together, and to enable the Company ultimately to do with one ship. Those objects had been secured. Since the cables were completed between Pernambuco and the River Plate there had not been one single interruption. The work had been done in such a satisfactory manner that the volume of traffic had increased 12½ per cent.; but that had produced less profit, owing to competitive rates, shifting of traffic, and bad exchange. They only required the restoration of order in Brazil and the re-establishment of the exchange upon a reasonable footing to enable the Company to again become remunerative. Under all the circumstances, the Board did not feel justified in recommending a dividend. At the present rate the receipts for the current half-year would be £9,000 less than those of the period under review.

Mr. C. W. Earle seconded the motion, which was adopted.

ELMORE'S PATENT COPPER DEPOSITING COMPANY.

The ordinary yearly meeting of Elmore's Patent Copper Depositing Company was held on Wednesday at the Cannon-street Hotel, Mr. J. Todhunter presiding.

Mr. J. L. Langmead, the secretary, presented the report of the Directors, which is given in another column.

The **Chairman**, in moving its adoption, first referred to the difficulty the new Board had had in arriving at the real position of the Company's finances owing to the way in which the accounts had been kept. He believed now, however, everything had been written off which ought to be written off. The Company had carried out every order which had been demanded, but owing to the coal strike this had only been done at considerable cost. The Wire Company had been a source of great anxiety to the Company. So long as they could use the Wire Company's furnaces all would be well, but the finances of that company were in such a condition that they might pass out of the control of the present Board at any moment. Mr. Atkinson, the chairman of the Wire Company, would probably explain certain arrangements which were in progress which might render any change unnecessary. The works were now in good order, and the Company would be ready to execute orders as soon as they could get the coal. They had actual orders to the extent of 65 tons of finished output, a large proportion of which had come to hand during the last six weeks. He was not at liberty to go into details, but there seemed to be an opinion that the Company's process was the only process of coating the tail shafts of big steamers, and in this way a trade seemed to be opening out to the Company apart from the trade which they had previously expected. The coal strike had cost the Company between £3,000 and £4,000; and this, together with the sum due from the Wire Company and other liabilities which the Directors were not aware of when they took over the management of the company's affairs, because they were not in the books, had reduced the working capital of the Company to £4,000, a sum which was absolutely inadequate to provide for the working of the concern. It remained for the shareholders to say whether they would provide the further capital for carrying on the works. What the Directors proposed was that debentures should be issued to the extent of £10,000, and his co-Directors and himself, to show the confidence they had in the concern, proposed to subscribe £1,300 of this. They suggested that the debentures should bear interest at the rate of 6 per cent., and proposed to make them redeemable at six months' notice at the rate of £102 for every £100 debenture. The share capital would have to be written off sooner or later, and it would be a great convenience to appoint auditors resident in Leeds. In conclusion, the Chairman said the shareholders must not go away with the impression that the Company was in difficulties. They had money in hand and copper to go on with, but they had not sufficient money or copper to execute the orders placed with them and those they had in prospect.

Mr. J. W. Dale seconded the adoption of the report.

Mr. J. J. Atkinson, one of the largest shareholders in the Company, and the chairman of the Wire Company, stated that the latter company had only one pressing claim—the claim of their bankers. On Monday week he tendered to the bankers the money they were entitled to, and he believed that in the course of a few days he would be able to give the Depositing Company the copper he had promised them. Like the Chairman, he thought the two companies ought to be amalgamated.—The report and accounts were adopted.

Copper.—The variations in the value of good merchantable copper have again been slight during the past fortnight, from £42. 1s. 3d. to £42. 10s. for cash, prices fluctuating more or less each day.

BUSINESS NOTES.

Northallerton.—The linoleum factory is now lighted by electricity.

Leyton.—The Local Board are seeking powers to supply electricity in the district of Leyton.

Grimsby.—The Town Council have decided to apply to the Board of Trade for a provisional order.

Monmouth.—The Corporation are applying for powers to supply electricity for public and private purposes.

Western and Brazilian Telegraph Company.—The receipts for the week ended November 17 were £3,115.

Newcastle.—The Electric Lighting Committee of the Town Improvement Committee has been reappointed.

Woolwich.—The District Board have under consideration a proposal to light the baths and Town Hall by electricity.

Northampton.—The Town Council have granted the application of Messrs. Smith Bros. to erect three telephone wires.

Upton.—It is proposed by the Cheshire County Council to light the projected new asylum at Upton by electricity, at a cost of £2,000.

Shrewsbury.—The Shropshire Electric Light and Power Company are applying for powers to supply electricity for public and private purposes.

West India and Panama Telegraph Company.—The receipts for the two weeks ended November 15 were £83 more than for the corresponding period.

Telephone Press, Limited.—This Company has been registered with a capital of £3,500 in £1 shares, to carry on business as printers and publishers.

Aberdare.—Mr. J. C. Howell, of 24, Queen Victoria-street, E.C., is applying for powers to supply electricity in a certain portion of the area of the Local Board.

Post Office Lighting.—The new General Post Office building in Aldersgate-street is about to be wired by the staff employed at St. Martin's-le-Grand. About 2,000 lamps of 16 c.p. will be required.

Paddington.—The Baths Commissioners have expressed their admiration for the way Messrs. Dawson and Hammond, of John-street, Edgware-road, have completed their work of lighting the hall by electricity.

Sydenham.—We understand that Messrs. Drake and Gorham have been entrusted with the rewiring of the entire installation at Westwood House, Sydenham, for Mr. C. J. W. Rabbits, where there are about 200 lights.

Dixon Patent Fog-Signal Company, Limited.—This Company has been registered with a capital of £4,000 in £50 shares, to acquire and turn to account certain patents relating to improvements in apparatus used in fog signalling.

Sutton (Surrey).—A further report by Mr. E. C. de Segundo is under the consideration of the Local Board. Mr. de Segundo suggests that it might be advisable for the Board to establish a small installation as a beginning.

Harrow.—The Local Board have decided to apply for a provisional order for supplying the district with electric light, and have also under consideration the erection of public baths and the extension of the boundaries of the district.

Personal.—Mr. F. Leonard, who for the past 25 years has been manager to Messrs. S. Pontifex and Co., gas, water, and electrical engineers, of 22, Coleman-street, has now acquired the entire business. He intends to retain the present title.

Derby.—The following have been appointed members of the Electric Lighting Committee of the Town Council: Aldermen Bemrose, Heathcote, Leech, Sowter, and Woodiwiss; Councillors Bottomley, Butterworth, Harrison, Haslam, Marsden, and Stone.

Camberwell.—The Vestry intend to apply to the Board of Trade for a provisional order authorising them to supply electricity within so much of their parish as is not already authorised to be supplied by the Crystal Palace District Electric Supply Company.

Ander's Telephone Company, Limited.—This Company has been registered with a capital of £10,000 in £1 shares, to acquire certain patents relating to improvements in telephones, and to carry on business as electrical engineers and telephone manufacturers.

Norwich.—The Town Council have decided to expend a sum not exceeding £40 for placing at the city lunatic asylum the electric light mains in culverts underground, and a sum not exceeding £40 for providing and fixing a suitable switchboard and connecting the dynamos.

Volk's Electric Railway.—We understand that Messrs. Johnson and Phillips are supplying for this railway a 20-kilowatt special heavy type Kapp dynamo, and that Messrs. Tangyes, Limited, are providing a 20-h.p. gas-engine, fitted with self-starter and all recent improvements.

Chatsworth.—The electric lighting of Chatsworth, which was entrusted to Mr. Bernard Drake by the Duke of Devonshire, has been successfully completed, and the whole plant started up without a hitch of any kind. We may shortly describe this installation in detail, it being unique in many respects.

City and South London Railway Company.—The receipts for the week ending November 19 were £879, against £899 for the same period last year, or a decrease of £20. The total receipts for the second half-year of 1893 show an increase of £181 over those for the corresponding period of 1892.

Agency —We learn that Mr. J. D Baillie, late installation superintendent for Messrs. J D F. Andrews and Co , London, S W , has been appointed Yorkshire representative for Messrs. C. A. Parsons and Co , electrical engineers, Newcastle upon-Tyne, with offices at Peacock's buildings, Park row, Leeds.

The Royal Exchange —The ceremony of turning on the electric light at the Royal Exchange, which work has been carried out by Messrs. J. G Statter and Co , was announced to take place yesterday. The Lord Mayor of London was to personally perform the ceremony of switching on the light for the first time.

New Swindon - Mr. Hamp reported at a recent meeting of the Local Board that the Electric Lighting Committee had met and recommended that Mr. Aldridge, electrical engineer, of Westminster, should be instructed to prepare a report on No. 1 district, together with an estimate of the cost. This was agreed to.

Telegraph Construction and Maintenance Company, Limited. The directors notify the holders of the £150 000 £5 per cent. debentures that they intend to renew the existing debentures, which mature on January 1, 1894, with debentures to an equal amount, to mature on January 1, 1899, and upon which interest will be payable half yearly at the rate of £5 per cent. per annum.

Folkestone.—The question of reappointing the Electric Light Committee of the Town Council was considered at a meeting of the latter last week Councillor Thompson contended that it had not been dissolved, and that it would remain in existence until the report was made The Mayor decided that the committee was still in existence After some discussion the Electric Light Committee was reappointed.

Poplar -The Works Committee of the District Board of Works have recommended that Mr. W. H Preece should be invited to report, at an expense not exceeding 50 guineas, upon the question of electric lighting and the application of the Poplar Electric Lighting Order, 1893, to the district, with particulars of the cost of the installation of the light. The recommendation of the committee has been adopted

Tenders for Dublin.—The Corporation of Dublin invite by the 14th proximo tenders for the extension of the buildings and the supply and erection of additional plant at their central station, Fleet-street Dublin Plans may be seen and specifications and forms of tender obtained, at the office of Mr. Spencer Harty, C.E , city surveyor City Hall, Dublin, on payment of one guinea, which will be returned to all persons sending in a *bonâ fide* tender.

Tenders for Barnet. The Barnet Local Board, as will be seen from our advertisement columns invite applications from those willing to take a transfer of, and to undertake and carry out, the powers granted by the Barnet Electric Lighting Order, 1893 Applicants are to state the system of lighting proposed, the charge for lighting the public lamps, and the terms upon which they would give the local authority the option to purchase the undertaking.

York.—Tenders are invited for the following articles during six months ending June 30, 1894, delivered carriage paid at the telegraph stores at York, for the North Eastern Railway Company: (1) telegraph apparatus, (2) telegraph wire and line stores. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York, and tenders must be sent to the secretary, at York, sealed and marked "Tender for Telegraph Stores," by December 5.

City of London Union.—The Infirmary Committee reported on Tuesday with regard to the expediency of lighting the infirmary with electricity, and recommended that the Board should give permission to their consulting an electrical engineer, at a fee not exceeding £10 10s , to advise the committee as to the installation of electric light, and that the committee report the result of their consultation to the Guardians. Mr. Lile moved the adoption of the report, and this was carried.

A New Cable.—The Commercial Cable Company have signed a contract with Messrs. Siemens Bros. and Co. for the manufacture of a new Atlantic cable, to be laid between Ireland and Nova Scotia in the ensuing spring This cable, which will be the third one owned by the Commercial Cable Company, will be 2,200 miles in length, and is to be made to a specification ensuring greater carrying capacity than any cable of the same length It will also be of special strength in order to resist ships' anchors in fishing waters.

Dublin.—At a meeting of the Corporation on Friday, Alderman Dillon moved several amendments to standing orders, and to add a new standing order as follows: "The Lighting Committee has charge of all matters relating to the lighting of the city, and all the powers hitherto vested in the Paving and Lighting Committee in connection with lighting matters, the quality and measurement of the gas supplied to the citizens, as well as the management and all matters relating to the electric lighting undertaking of the Corporation." The motion was not carried.

Faversham.—An installation of the electric light has been fitted on the premises of Mr. Henry S. Tett, ironmonger, Market street The system of wiring adopted is Andrews's patent. The plant consists of an 8 h.p. Otto gas engine, a Crompton continuous-current dynamo, and a battery of accumulators. The last mentioned are charged during the day, and will supply some of the lamps by themselves, or, if all the lights are required at once, the accumulators and the dynamo are run together, the former acting as a regulator and keeping the light steady Over 60 lamps, of 8 c.p., 16 c.p., and 50 c.p., have already been fixed, and others are in course of preparation. Mr. Tett is the agent for Faversham and Sittingbourne for Andrews's system of wiring.

Chichester.—As mentioned in our last issue a report on electric lighting has been presented by Councillor Prior to the Sub Committee of the Lighting Committee of the Town Council. Mr Prior states that he had consulted an electrical engineer upon the probable cost of lighting the town by electricity. The engineer had visited the city and gone fully into the matter, and had sent a report on the subject. The conclusions he arrived at were that the initial cost of lighting the principal streets of the old city with electricity would be from £12,500, as a low estimate, to £14,000 as a high one. The annual expenditure would be about £2,791. The revenue should be about £3,300.

Wallsend.—The Wallsend, Willington Quay, and Howdon Joint Hospital Board have considered a letter from the medical officer asking the Board to take the necessary steps to get gas laid on at the hospital. The Clerk mentioned at a meeting of the Board, that estimates of the cost of lighting the hospital by gas and by electricity had been obtained In respect to the former, the cost of laying a 2in. main would be £100, and of a 3in. main £150. Another estimate for the gas was £150 for 3in mains and £60 for the necessary fittings. An estimate for lighting the hospital by electricity, including complete lighting, installation, etc , for 50 separate lights was £138. 10s. by steam, and £184 by oil The Rev. J Hughes moved that the hospital should be lighted with oil, and this was adopted

Oswestry.—The Town Clerk mentioned at a meeting of the Town Council and Local Board last week that a notice for the provision of an electric light supply had been applied for for Oswestry by the Oswestry Electric Lighting and Power Company, and that he thought it would be well to refer it to the committee that had already been considering it for further consideration and report. Before December 20, the draft provisional order was to be deposited in various places in London, and also with himself, for perusal by the Council The Council would then have a right to go into the matter, and make any objections or observations to the Board of Trade they might think necessary until January 15 next year. There would thus be ample time for the consideration of the matter. At the present time they had no data to go upon, because the draft provisional order had not been seen by anyone in the employ of the Town Council. The matter was referred to the committee.

Belfast —The lighting of Queen's Quay is about to commence. The question of the use of electric light had been under the consideration of the Harbour Commissioners for a long time, and a practical step was taken in the matter towards the end of last year, when the tender of Messrs. Siemens Bros. and Co. was accepted for lighting the Queen's Quay, the Abercorn Basin, and the Hamilton Graving Dock. The construction and erection of the installations are superintended by Mr. George Combe, electrical engineer, Belfast, on behalf of the Commissioners. The total distance between the extreme ends of the circuit, beginning at the Queen's Bridge, is about 1,000 yards, the generating station being situated about midway on the Queen's-road, opposite the Abercorn Basin. The lamps comprise 19 arc lamps, thoroughly protected from the weather, and provided with opal or fluted wired globes suspended overhead on wrought-iron lattice masts 40ft. in height, and fitted with hoisting gear of wire ropes for lamps. The three dynamos in use will be worked by a high pressure non-condensing engine, capable of giving 40 actual horse power.

Hanley.—The scheme for lighting this town by electricity is being pushed on by the committee in whose charge the matter is placed, and there seems a probability of the town reaping the advantage of the improved system of lighting early in 1894 Mr Joseph Lobley, borough engineer and surveyor, has informed a Press representative that the work was progressing satisfactorily. The building of the chimney shaft has just been completed, and the cap and lightning conductors are now being placed upon it. The boiler house and engine and dynamo rooms are nearly in a state of completion, and the work of roofing them in is in progress, whilst as soon as this is finished the engines and dynamos, which are already made and ready for fixing, will be put in. The seven-ton travelling crane has also been made, and is quite ready for erection. With regard to the electric mains, those for actual distribution throughout the whole of the compulsory area, which comprises the central portion of the town, have been laid. The committee have drawn up and will shortly publish a pamphlet on the subject, in which they will inform the public that the work is being rapidly pushed forward, and express the hope that very early in the coming year they will be able to supply the current.

Elmore's Patent Copper Depositing Company.—In their report for the year ended June 30, the directors state that a mistake was made in the allotment of preference shares, 195 of which were not taken up After stating that all the efforts of the directors were frustrated by the coal strike, the report states that on the question of orders the books show orders on hand for 126 048lb., against 28 391lb at June 23 "A steady trade is being done in coating hydraulic rams and building up calico rollers. The delay caused by the coal strike has been very hard on the resources of the Company, which were, at best, barely adequate, as shareholders will remember; besides which, several considerable payments have had to be made to meet liabilities incurred by the old Board, and which did not appear in the books and could not have been included in the estimates submitted by the present directors; consequently, if a large trade is to be done, more money will be required to restore sufficient capital for furnishing the £10,000 worth of copper originally stated as being necessary. It will be evident that before dividends can be paid, even on the preference shares, it will be necessary to write down the value of the ordinary shares so as to wipe off the amount standing to debit of profit and loss. As an extraordinary general meeting of the shareholders

will be required to carry out the necessary resolutions, the directors intend taking the needful measures for that purpose." The loss for the year is £13,655, which, added to the debit balance of £7,862 as at June 30, 1892, makes the total loss £21,517.

Telephony at Liverpool. — Telephonic communication has recently been established for the Corporation connecting the offices of the water engineer in Dale-street, Liverpool, with the water supplies of Lake Vyrnwy, the Rivington Reservoirs (North Lancashire), and the houses of the reservoir keepers and walksmen along the lines of aqueducts. The work has been carried out to the specification of the city water engineer (Mr. J. Parry, M.Inst.C.E.) by Messrs. W. A. Shaw and Co., electrical engineers, of Warren-street, Stockport, under the personal supervision of the partners. The system is entirely on the metallic circuit principle, and the wires are carried as nearly as possible along the lines of aqueducts. The total distance of lines as laid is about 115 miles. The line wire is throughout of 12½ copper, and about 16½ tons of this wire have been used on the work, as also about 2,300 poles and 5,000 insulators; 5½ miles of line have been laid underground between Prescot and Oswestry, the cable being the lead-covered telephone cable of the Fowler-Waring Cable Company. They are in all 26 stations connected on the telephone system. The instruments used are of the Consolidated Telephone Company's Gower-Bell transmitters and bell receivers, with magneto signalling bells. In connection with the signalling arrangements, Messrs. Shaw have introduced various improvements not before associated with such work. In addition to the telephonic communication, there are also alarm contacts to valves and for overflows, ringing bells at the nearest signalling station.

Result of Dewsbury Tenders. — For works required in erection of an electric lighting station within the borough, for the Corporation (Mr. Henry C. Marks, A.M.I.C.E., borough engineer):

M. Scott, Earlsheaton, near Dewsbury	£3,418	4	4
B. Graham and Sons, Huddersfield	3,423	4	0
E. Chadwick and Sons, Staincliffe, Dewsbury	3,562	0	0
C. Whitehead and Sons, Ravensthorpe, near Dewsbury	3,614	11	2
Crabtree and Denton, Dewsbury	3,695	18	0
W. and J. Milner, Mirfield	3,766	5	0
Holme and King, Liverpool	3,843	9	3
W. Scott and Son, Dewsbury	3,940	10	0
J. E. Johnson, Leicester	4,160	14	0

For extra only for glazed-brick facing in engine-room, and for extra only for Helliwell's patent glazing in roofs:

	Glazed brick.			Glazing.		
Scott (accepted)	£140	0	0	£28	9	6
Graham	177	10	6	25	17	6
Chadwick	236	14	0	21	10	0
Whitehead	167	13	3	28	10	0
Crabtree and Denton	147	18	9	31	10	0
Milner	236	14	0	31	10	0
Holme and King	118	7	0	31	1	0
W. Scott	240	0	0	28	9	3
Johnson	177	10	6	30	0	0

Kendal. — When the question of the proposed purchase of the gas and water undertakings was discussed at a meeting last week of the Town Council, Councillor Hargreaves said he blamed the committee for not calling in the services of an electrical engineer to advise with them before offering to purchase, and so far as he understood, the committee never even considered the question of gas *versus* electricity. At the last Corporation meeting he called attention to the question of electricity and gave statistics and figures to show that in Kendal the electric light could be produced as cheap as gas—namely, 3s. per 1,000ft. He contended that for an expenditure of £25,000 they could put in a steam electric light installation that would supply the town, both public and private lighting, with as much light as at present, at as cheap a cost as gas, and leave a profit. He strongly advised them to drop at once all proceedings for purchase and let the directors carry on the good work of giving pure water. They would give a better supply sooner and much cheaper than the Corporation could. While they were improving the water supply let them put in the electric light. They had powers to this at a cost of about £100, whereas it would cost them £1,500 to £2,000 to get parliamentary powers to buy the gas company. If they did not do this some private company would do it, and they would have another monopoly set up in their midst. He moved that negotiations for the purchase of the gas and waterworks be at once dropped, and that steps should be at once taken to supply the town with the electric light. Councillor McKay seconded, but the motion was rejected.

Charges for Current at Manchester. — The following are the rates and methods of charge for the supply of electricity by the Manchester Corporation: The Corporation will, at the option of the consumer, charge for the supply of electricity either at the rate of 8d. per unit as measured by meter, with a minimum charge of 13s. 4d. per quarter, or at the rate of £3 per quarter for every unit per hour consumed when all lamps or other consuming devices are in use, and 2d. per unit as measured by meter; that is to say, at a fixed charge of 4s. per quarter for each 16 c.p. lamp, and 2d. per unit as measured by the meter. If desired, the Corporation will supply a meter or meters at a rental of 10 per cent. per annum on the cost of such meters. The Corporation have under consideration the adoption of a method of charge by which the use of a meter will be rendered unnecessary, thereby avoiding expense to small consumers. If the lamps and other consuming devices are used to such an extent that their total use amounts to less than 480 hours per annum of the whole of the lamps and other consuming devices, it is more economical to adopt the charge of 8d. per unit; if, on the other hand, the total use amounts to more than 480 hours per annum, the charge of £3 per quarter and 2d. per unit will be less. A Board of Trade unit of electricity will supply 15 16-c.p. lamps or 30 8-c.p. lamps for one hour, if the lamps are suitable. A Board of Trade unit of electricity will supply two arc lamps of 10 amperes for one hour. A Board of Trade unit of electricity will, with a good motor, give more than 1 h.p. effective for one hour. Ten units, with incandescent lamps of 16 c.p., produce an amount of illumination about equal to 1,000 cubic feet of gas.

Swansea. — Alderman Tutton, in moving the adoption of the minutes of the Property Committee of the County Borough Council a few days ago, referred particularly to the following minute: "The town clerk informed the committee that several companies had given notice of their intention to apply to the Board of Trade for a provisional order for the supply of electricity in this borough. Resolved, that the assent of this Corporation be refused in respect of each application, and that a petition under the common seal be presented to the Board of Trade requesting that Board not to sanction any order that may be applied for, it being the intention of the Corporation to at once enforce the provisions of the Swansea Electric Lighting Order, 1889; also resolved, that the sub-committee be reappointed." Alderman Tutton having explained the position of the committee, the Town Clerk, in reply to questions, said the position was this—that the Corporation could no longer sit down and allow their powers to become inoperative. If they allowed it to go forth to the Board of Trade that they merely sought for powers to allow them to remain dormant, the Board of Trade was very likely to set them aside, and grant one of the applications from private firms. What was wanted now was an assurance to the Board of Trade that they were serious in regard to electric lighting, and that they would either proceed at once to carry it out themselves or would commission a firm to do it. The three years had passed and they must do something. Alderman Martin said it was only right that the Board of Trade should know that they had already done something in the matter. They entered into communication with a firm before they got the order; but after they got the order that firm doubled its estimate—— Alderman Tutton: And wanted a contract for 21 years instead of seven. Alderman Martin said that was so. If the firm in question now proved more reasonable, he was sure the Corporation would not be disinclined to enter into a contract in the matter. The minutes were carried. The Swansea electric lighting order being about to expire, Messrs. Crompton and Co. Limited, are about to step into the breach and ask the Board of Trade for a provisional order to light Swansea by electricity.

Lighting at Nottingham. — Preparations for the installation of the electric light, under the Nottingham Electric Lighting Order, 1890, have reached a definite stage. Acting under the advice of the borough electrical engineer, Mr. Herbert Talbot, the Corporation sanctioned a scheme which included the erection of a central station on the site known as "Holborn Villas," between Talbot-street and Wollaton-street, and the laying of mains in the "compulsory area" and in two other streets which formed convenient connections between streets in that area. Practically, the whole of the central portion of the town will be traversed by these mains. The mains are being laid on the Callender-Webber system. The ordinary work of excavating, etc., is being carried out by Corporation employés, but the contract for the more special work has been placed with Callender's Bitumen, Telegraph, and Waterproof Company, Limited, who are to maintain the system for three years, and at the expiration of that time hand it over to the Corporation in a condition equal to passing a test laid down in the specifications. At the central station in Wollaton-street, building operations were commenced about August, and though even now a general idea may be formed of what it will eventually be, some delay has taken place owing to the failure, on account of the coal trade dispute, to obtain glazed bricks. Following Mr. Talbot's suggestion, the Corporation have decided that the buildings shall be large enough to contain plant for supplying 13,000 8-c.p. lamps, but for the present plant for 10,000 lamps will be put down. The buildings are so designed, however, that should necessity arise they can easily be extended. This chimney, when erected, will be 160ft. in height. The three boilers with which the building will be fitted at present are by Mr. Edwin Danks, of Oldbury, Birmingham. Green's economiser has already been fitted, and in connection with this Berryman's feed-water heater will also be used. The contract for the engines and dynamos is being carried out by Messrs. Siemens Bros. and Co. The engines are of the Willans type. The station, when finished, will be creditable to the Corporation and the contractor, Mr. F. Messom, of Nottingham. The method to be used is the low-pressure continuous current three-wire system. It is anticipated that the work will be completed by April next, and people in business along the streets in which the mains are being laid will be able to have the electric light supplied to them forthwith. A number of applications for the light have already been sent in. It has not been decided by the Corporation that the streets shall be lighted with electricity. That will probably form the subject of future consideration. The cost of the light to the consumer has not yet been fixed. The total cost of the scheme will be about £45,000. The site of the buildings cost £10,175, and the capital outlay on the buildings, plant, mains, and installation will be about £34,000 or £35,000.

Guildford. — A public meeting was held last week to consider the desirability of introducing the electric light. Alderman J. Mason, J.P., who presided, said that he had hoped that electric lighting would have been introduced by the Corporation, and the question was referred for the consideration of a committee. The

expense, however, according to their report, would have been so enormous that he did not think the public would have approved of the Corporation incurring it he believed it was £20,000, or something of that kind; and he did not think that the Corporation would in the present position of affairs have been justified in going to anything like that expenditure. Mr. Sidney Sharp (who was called on by the chairman) said that the object of the meeting was to interest them in the establishment of an electricity supply station The cost of a provisional order was from £150 to £250 it varied according to whether there was any opposition or not but one must be prepared to go to the latter sum if necessary The formation of a company would probably cost another £150, and the object they had in view that evening was the provision of the £400 with the ultimate prospect of forming a Guildford Electricity Supply Company He did not see why a company in Guildford, which has a very good business centre, should not pay dividends as well as companies to which he referred. He had stated at a previous meeting that a sum of £10,000, roughly would be required for the erection of a station for 4,000 8 c.p. lamps He had been told since that that possibly was rather a large sum to raise for a new undertaking If that were so, they would be content with a station of less capacity, but the reason he suggested the above number was to be prepared for extensions in the future It was desirable, where possible, that the buildings and the mains should be made with a view to the future, though the other plant could be added to according to the requirements He thought that those who were willing to put their money down for obtaining the parliamentary powers should be entitled to remuneration in proportion to the risk they ran, and founders' shares were probably the best way to meet that. After a dividend of 5 per cent had been paid on the ordinary shares founders' shares should take a certain proportion of the rest of the profits Mr Sharp pointed out that, in addition to the electricity required for lighting purposes, it would no doubt be a great advantage in many places as a motive power, for which it could be used very economically. If the application for a provisional order was not proceeded with immediately it would have to be postponed for a year, and, therefore, if possible something definite should be done that evening towards ensuring that the application to the Board of Trade should be carried through Councillor Salsbury said that some time or other there was bound to be an electric lighting company in Guildford, and he had not the slightest doubt but that if a company were started it would pay, because he was quite certain that the majority of the tradesmen, after they saw the advantage of the electric light, would become purchasers of it If a provisional order were once obtained, he did not believe there would be much difficulty in floating a company. With the view of testing the opinion of the meeting, Mr. C. Holden proposed, and Mr. A. F. Asher seconded, a resolution in favour of electric lighting being introduced into the town, and this was carried. A committee was then formed to further promote the scheme.

PROVISIONAL PATENTS, 1893.

NOVEMBER 13.

21589. **Improvements in electrical signalling, recording, and detecting apparatus.** Thomas Davis and Edward Davis, Lord street, Liverpool

21592. **Improved means of obtaining electrical contacts, disconnections and reversing currents for operating electrical indicators or signals.** Hugh Reid, Belmont, Springburn, Glasgow (Complete specification)

21609. **A method and apparatus for the production of light by electric and electromagnetic oscillations and vibrations** Alfred Rene Upward, 150, Holland-road, Kensington, London

21619. **An electro deposit of zinc.** Joseph Nixon, St. John's-square, Clerkenwell, London.

21624. **Improvements in or connected with electrical storage batteries** Edwin Augustus McLachlan, 11, Furnival-street, Holborn, London.

21628. **Improvements in telegraphy.** Patrick Bernard Delany, 24, Southampton buildings, Chancery lane, London. (Complete specification)

21629. **Improvements in cable and submarine telegraphy.** Patrick Bernard Delany, 24, Southampton buildings, Chancery lane, London. (Complete specification.)

21630. **Improvements in telegraphy.** Patrick Bernard Delany, 24, Southampton-buildings, Chancery-lane, London. (Complete specification.)

21631. **Improvements in electrolysis and in apparatus therefor.** William Hay Caldwell, 24, Southampton buildings, Chancery lane, London.

21637. **An automatic electric signal for tramways and the like** Henry Oakden Fisher and William Walter Phillips, 22, Southampton-buildings, Chancery-lane, London.

NOVEMBER 14.

21714. **Improved electric exchange systems with apparatus therefor, applicable also for telegraphic and electric typewriting purposes** Samuel Dickinson Williams Moorlinch House, Clytha Park, Newport, Monmouthshire.

21716. **Improvements in the means of producing electric light.** *James Clegg, Brampton, West Norwood, London.*

21734. **Improvements in dynamo-electric machines** David Henry Wilson, 321, High Holborn, London. (Complete specification)

NOVEMBER 15.

21812. **Improvements in electrical means of advertising.** Alfred Rene Upward, 150, Holland-road, Kensington, London.

21850. **Improvements in voltameters.** Henri Adrien Naber, 4, South street, Finsbury, London. (Complete specification.)

NOVEMBER 16.

21932. **Improvements in electric cigar-lighters and analogous objects** Friedrich Wilhelm Schindler, 433, Strand, London

21933. **Improvements in electrical cooking appliances.** Friedrich Wilhelm Schindler, 433, Strand, London.

21958. **Improvements in and relating to electric lamps for bicycles and similar vehicles.** Henry Harris Lake, 45, Southampton buildings, Chancery lane London (George Mayr, United States)

NOVEMBER 17

21966. **An improved electrical drop indicator.** Ebenezer Beal, 167, Highfield road, Seeley, Manchester.

22027. **Improvements in electric instrument protectors** Henry Reason, 111, Gloster road Brighton

22030. **A method of applying electricity to the mechanism of lights for lighthouses buoys beacons, and the like.** Henri Marie Hubert, Comte Delamarre 28, Southampton buildings, Chancery lane, London

22032. **Improvements in accumulator batteries** Georges Rene Blot, 28 Southampton buildings, Chancery lane, London.

22053. **Improvements in or connected with so-called "dry" electrolytes for secondary batteries.** Villeroy Corney Doubleday, 77, Chancery lane, London. (Max S. ...mann, Germany.)

NOVEMBER 18.

22075. **Improvements in electric furnaces for welding or heating metals** Charles Frederick Parkinson and the Lancaster Railway Carriage and Waggon Company, Limited, 6, Bank street, Manchester.

22089. **Compound plates for etching purposes, consisting of zinc electrically plated with copper or the like.** Hermann Bernert, 38, Alexander-strasse, Berlin.

22131. **Improvements in switches for controlling electric current circuits in parallel supply systems** William Lowrie, 433, Strand, London. (Complete specification.)

SPECIFICATIONS PUBLISHED

1892.

9347. **Electrolytic decomposition of halogen compounds.** Kellner (Second edition)

9799. **Electrolysis of alkaline chlorides** FitzGerald. (Second edition.)

19393. **Electric battery apparatus** Froggatt.

19720. **Rectifying alternating currents.** Pollak.

19959. **Measuring electricity.** Humphreys and Friese Greene

20598. **Electric accumulators.** Therye and Oblasser.

20610. **Telephone circuits** Anders and Kottgen.

21602 **Electric meters.** Scott.

22539. **Dynamo electric machinery.** Spence and others.

23075. **Electric switches.** Raworth.

23392 **Telephony** Hutin and Leblanc

1893

516 **Measuring and recording electric currents** Lake. (Weston.)

17646 **Telephone switch.** Ness

18170. **Electrical contacts.** Raworth.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11¼
— Pref.	—	13
Electric Construction	—	1¾
House to House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22¼
Liverpool Electric Supply	5	6½
	3	4¼
London Electric Supply	5	1
Metropolitan Electric Supply	—	7¾
National Telephone	5	4¾
St. James', Pref.	—	8¼
Swan United	3¾	3⅛
Westminster Electric	—	5¼

NOTES.

Fire Alarms.—A new type of fire alarm has been devised by a member of the Cardiff police force.

Queen's Hall.—This hall, situated in the West-end and opened the other day, is lighted throughout by electricity.

Shipley.—The Local Board have decided to apply to the Board of Trade for sanction to borrow money to acquire the tramways.

Scientific Toys.—Mr. James Swinburne discoursed to an audience at Victoria Hall last week on the scientific aspect of penny street toys.

The Brighton-Rottingdean Railway.—The share list of the Brighton and Rottingdean Seashore Electric Tramroad Company was closed yesterday.

Accident.—On Saturday, whilst William Musgrave was attending to the electric light plant at West Hartlepool, he was caught by the machinery and killed.

Book Received.—We have received for review copy of "Helical Gears: A Practical Treatise," by "A Foreman Patternmaker," and published by Messrs. Whittaker and Co.

Supply and Measurement.—Prof. Silvanus P. Thompson, F.R.S., has delivered a lecture at the Victoria Rooms, Bristol, on the "Supply and Measurement of Electricity."

Obituary.—The death is announced of Mr. Joseph Heywood, who was for 41 years lecture-assistant and steward of the chemical laboratories at Owens College, Manchester.

Personal.—We are informed that *Industries and Iron* has lost the services of Mr. James Swinburne as electrical editor, but that this gentleman will remain a contributor to that journal.

Foremen Engineers.—The annual dinner of the Newcastle and District Association of Foremen Engineers and Mechanical Draughtsmen has been held in the County Hotel, Newcastle.

"Not an Injun."—One of the speakers during the discussion at the Institution last week declared that, as he was not a wild Indian, he would not call Niagara, "Nee-à-gahrra," but Ni-ag-ara.

Lightship Communication.—Telephonic communication between the Gunfleet lightship and the coastguard stations at Harwich, Walton-on the-Naze, and Clacton-on-Sea has been completed.

The Azores Cable.—The Eastern Telegraph Company announce that telegraphic communication has been established between the company's station at Lisbon and the Island of Graciosa, in the Azores.

The New Mauritius Cable.—The new cable connecting Mauritius and the Seychelles with Zanzibar, and thus with Europe, was inaugurated on the 25th ult. by the governor, Sir Hubert Jerningham.

City Lighting.—A correspondent asks in a City paper for an explanation of the cause of the extinction on Friday last, for 20 minutes, of the incandescent lamps used in private installations in Moorgate-street.

Society of Engineers.—The next ordinary meeting of this society will be held at the Town Hall, Westminster, on Monday. A paper will be read on "Some Practical Examples of Blasting," by Mr. Perry F. Nursey.

"Don't Read This."—"Do you know," asked *l'homme terrible* (not *l'enfant terrible* this time) as he entered our office the other day, "why are lamp trimmers are so courteous? "No," was the response. "Because," he replied, "they are po-lite men."

Transmission of Power.—Several new schemes are under consideration for the electrical transmission of power from distant parts to Milan. The Societa Italiana per le Condotte d'Acqua is now transmitting 1,000 h.p. from Tivoli to Milan.

Power Station v. Central Station.—The general term of "central station" is rather ambiguous. Prof. S. Thompson suggests that "power station," as adopted by Prof. Forbes in his paper concerning Niagara, is decidedly better, the words "central station" being rather misleading.

Society of Arts.—On Monday, at 8 p.m., the second Cantor lecture on "The Art of Book and Newspaper Illustration," by Mr. Henry Blackburn, will be delivered. On Wednesday, at 8 p.m., a paper will be read by Mr. Frederic Villiers on "An Artist's View of Chicago and the World's Fair."

Industrial Applications of Electricity.—The course of public lectures which are given annually at the Conservatoire des Arts et Metiers in Paris has just commenced for the current year. M. Marcel Deprez lectures every Monday and Thursday on the industrial applications of electricity.

The Decimal System.—The Leeds Chamber of Commerce have resolved, in view of the expected discussion at the coming conference in London, to recommend the adoption of a metrical system of weights and measures, and that the pound sterling should be taken as the unit.

Students of the Institution.—A meeting of the students of the Institution of Electrical Engineers will be held this (Friday) evening at 28, Victoria-street, Westminster. A paper on the following will be read: "The Mechanical Testing of Electro-Deposited Films of Metal," by Mr. Arnold Phillip.

Dynamo-Electric Machines.—The second edition in French of Prof. S. P. Thompson's book, "Traité Theorique et Pratique des Machines Dynamo-Electriques," has just been issued by Messrs. Baudry and Co., 15, Rue des Saints-Pères, Paris. The work has been translated and adapted from the fourth English edition.

Colliery Managers.—A meeting of the Association of Colliery Managers took place on Saturday in Edinburgh, the president, Mr. William Roy, Holytown, in the chair. The discussion on Mr. Weir's paper on "The Application of Electricity to the Development of Dip Workings and other Purposes," was resumed and closed."

Traction at Croydon.—An important movement has been started by the Corporation, who are seeking powers to construct tramways in the borough to be worked by animal or mechanical power. The Corporation have had facilities for judging the advantages of mechanical traction, and electrical engineers should take a "stitch in time."

The Institution.—The annual general meeting will be held at 25, Great George-street, Westminster, S.W., on Thursday, the 14th inst. The annual report of the Council will be presented, and the election of Council and officers for the year 1894 will take place. "The Electrical Transmission of Power from Niagara Falls" will be further discussed.

The Stopping of Trolley Cars.—A Rochester (U.S.) man has devised a plan by which a trolley street car can be stopped almost instantaneously, or within a space of 3ft., while the car is going at full speed. As he omits,

however, adds the *Railway Review*, of Chicago, to provide for stopping the passengers, it is only fair to presume they will object.

Elieson Company v. The Earl of Galloway.—With reference to this case, which was reported in our last issue, Mr. Watson Smith, editor of the *Journal of the Society of Chemical Industry*, writes that he is not the person bearing the name of "Watson Smith" who figured in that case, and that they are not connected by any bond of relationship.

Private Bill Legislation.—The time for giving notice in the *London Gazette* of all English and Welsh Private Bill legislation for next session expired on Tuesday, when notice had been given of 154 Bills. Two of these Bills are promoted by the Central London Railway Company, and the Charing Cross and Hampstead Electric Railway Company.

Royal Institution.—The annual course of lectures for children will this Christmas be delivered by Prof. James Dewar, F.R.S. The subject will be "Air—Gaseous and Liquid," and the first lecture will be delivered in the theatre of the Royal Institution on Thursday, December 28. The next general monthly meeting of the members will take place on Monday next.

The Attack on Gas.—The agitation in North London against the high price charged for gas is still proceeding. Mr. J. Rowlands, M.P., who delivered an address on the subject on Tuesday evening, said that the electric light would soon become more used, and then the gas companies would be at a discount. Hammer away, ye Finsburyites, but go in for electricity.

Exhibition of Inventions. — An international exhibition of inventions, under the auspices of the Society of Industry of Copenhagen, which is to be opened on the 5th January next, will consist of models and specimens and illustrations of inventions of interest to Scandinavia. Messrs. W. P. Thompson and Co., 6, Lord-street, Liverpool, have the matter in hand.

Steering Balloons.—In connection with the revolution proceeding in Brazil, it is stated that a great balloon has been constructed for operation against the insurgent fleet, and that a quantity of bombs has been prepared for its special use. The balloon is said to be equipped with an electric motor, which, it is stated, will steer the balloon perfectly. We have heard of this before, and shall no doubt again.

"Venus" Incandescent Lamps.—We note that Mr. G. Straus, who has occupied temporary offices at 158, Strand, W.C., has now removed to more commodious offices at 130, Queen Victoria-street, E.C., where he has on view a large assortment of "Venus" incandescent lamps. It is claimed for the "Venus" lamp that its life and efficiency are unsurpassed, whilst at the same time the prices are low.

Traction at Morecambe.—The chairman of the Morecambe Tramways Company, in reply to a question put on Wednesday by a shareholder, as to the advisability of adopting electricity as the motive power, replied that at present this was impracticable, the local authorities objecting to the overhead system, and the cost of carrying and charging accumulators being at the present time less economical than horse traction.

Lights in Loch Fyne.—In answer to Mr. Macfarlane, Mr. Mundella remarked in the House of Commons a few days ago that the Board of Trade have no power of initiation in the establishment of lights, and that their duty is confined to sanctioning or refusing applications submitted to them by the general lighthouse authorities. The Commissioners of Northern Lighthouses have at present some large and costly works in hand.

The "Medical Battery" Company, Limited.—The further hearing of the charge of fraudulent conspiracy brought against Cornelius Bennett Harness, managing director of the "Medical Battery" Company, Limited, James M. McCully, C. B. Hollier, and W. R. Sellman (otherwise Dudley Towers) was resumed by Mr. Hannay at the Marlborough-street Police Court on Wednesday and yesterday. The case was again adjourned until to-day (Friday).

Telegraphic Addresses.—Mr. Henry Sell, in reference to his projected "Directory of Registered Telegraphic Addresses," states that he has now received the whole of the lists from the Post Office. The reply to the Postmaster-General's query as to whether firms would consent to his giving him their various registered telegraphic addresses has been all but unanimous in favour of the publicity, the number objecting being only a few hundreds out of some 45,000 persons or firms applied to.

Earthquakes and Cables.—On Monday, at the London Institution, the Rev. H. A. Boys delivered a lecture on the subject of earthquakes in the Grecian archipelago. The terrible earthquake on the south-west of the Morea in 1886 was felt at Zante. As an illustration of the crumbling effects produced, the lecturer remarked that the submarine cables from the island were snapped, and that when the engineers came to relay them it was found that the sea bottom was from 400ft. to 1,000ft. lower than before.

Lighting Mail Cars.—The German Postal Department has recently been testing the practicability of lighting mail cars with incandescent lights instead of with gas. The current has been supplied by storage batteries of a capacity sufficient to keep eight lamps of 12 c.p., each burning brilliantly and steadily, at a cost of ⅜d. a light per hour, against an expense of ½d. a light per hour when gas was used. Thus the electric light seems to offer advantages from an economical as well as a hygienic point of view.

Rectified Currents.—The Société d'Eclairage et de Force at Paris have granted a license for the Leblanc-Hutin patents to the firm of MM. Farcot. The latter will at once commence the manufacture of apparatus of large powers for rectifying alternate currents. In this connection it is interesting to note that in the electric light works which are on the point of being started at Saint-Ouen Epinay, it is intended to use alternate current produced at Saint-Ouen for the charging of accumulators at Epinay by the use of a rectifier.

Power Transmission to Macerata.—This Italian town is now lighted by electricity, the current being transmitted a distance of four miles. Water power is used, there being two Escher-Wyss turbines coupled by means of Raffard couplings to two Oerlikon dynamos giving current at 2,400 volts. The conductors are carried overhead, and the loss on the line is 300 volts, the pressure of the current on reaching Macerata being 2,100 volts. A portion of the current is used for public incandescent lighting in series, and the remainder is distributed on the three-wire system.

Seismology.—Hitherto, the prime difficulty of seismologists has been to ascertain the exact time at which an earthquake shock strikes a given locality, the data being, even within an area of not many yards, often very vague. To obviate this inaccuracy, we gather from *L'Elettricista*, as quoted in *Nature*, that Dr. A. Cancani, of the Rocca di Papa Observatory, has devised an ingenious electrical instrument. This, it appears, consists of a chronometer, the face of which is photographed by "the light of an

incandescent lamp, lighted for about a quarter of a second by a current established automatically by the shock."

The Antwerp Exhibition.—Arrangements are now in progress for the adequate representation of Great Britain and Ireland at the forthcoming international exhibition at Antwerp, which is to be opened in May next. The exhibition includes industrial, scientific, and artistic productions, maritime, Colonial and African sections, etc. The scheme has received the approval of the London Chamber of Commerce and the Associated Chambers, and a programme indicating their co-operation will shortly be issued. Meanwhile, information will be supplied in London by the Chamber of Commerce.

Traction at Leeds.—The Highways Committee of the City Council, on Wednesday, considered the subject of applying electricity as a motive power on the tramways. This undertaking is shortly to come into the possession by purchase of the Corporation, and it is thought that opportunity might be taken of the change to introduce electricity instead of horse and steam power. Mr. R. Hammond attended the committee meeting, and conferred with the members as to the different systems in operation throughout England and other countries. He described the conduit system in use in Budapest, and replied to numerous questions put to him by members regarding the working of the overhead wire system.

"Standard Tables for Electric Wiremen."—A copy of the fourth edition of "Standard Tables for Electric Wiremen," by Mr. C. M. Davis, has been forwarded to us by the W. J. Johnston Company, Limited, of 167-176, Times-building, New York. In addition to giving standard tables for wiremen, the booklet contains instructions for wiremen and linesmen, useful formulæ and data, and the latest revisions of the insurance rules of the Underwriters' International Electric Association. The wiring tables are according to the Brown and Sharpe gauge, and this, combined with the fact that the costs are given in American money, renders the book of greater value to those in the United States than to those in the United Kingdom.

The Central London Railway.—As mentioned in our last issue, a Bill will be introduced into Parliament next session to extend the time within which to construct the Central London Railway (authorised in 1891) from Shepherd's Bush, under Uxbridge-road, Oxford-street, High Holborn, Cheapside, to the Mansion House, and subsequently extended in 1892 as far as Liverpool-street Station. The time for taking the land required will, if not extended, expire next year. It is understood that the Bill will also contain clauses for the purpose of relieving the company from the payment of compensation for the subsoil through which the railway will pass, which was a right conceded to landowners, after great opposition on the part of the company, by a committee of the House of Commons. The company do not intend, as some papers have erroneously stated, to work the line by some power other than by electricity.

A New Police-Signal System.—A demonstration of Davis's improved signal system took place last week in Liverpool. The invention is that of Mr. Edward Davis, an Englishman resident for some years in America, and who there gained experience under some of the best firms. Through the medium of a metal box fixed at any point throughout the city a system of communication with the head office can be established. By means of a key, with which the policeman or watchman is entrusted, he opens the box, and should he want to bespeak the services of a patrol waggon or ambulance, or raise an alarm of fire, he has only to press a particular knob and the telegraph wire connecting the box with the head office instantly transmits the message to its destination. Not only does it do this, but it is said to automatically record on paper the time at which the signal was received, the number of the key by which the box was opened, and that of the box itself, thereby successfully individualising the policeman making the signal or sending the message.

Regulating Clocks by Electricity.—In our issue of the 6th October reference was made to an improved system of regulating clocks by electricity. A demonstration of the method was given last week by the Standard Electrical Time-Recording Company, Limited, at 39, Victoria-street. By this system time-recorders to any number can be governed by a self-contained installation, and every station clock upon a railway system can be controlled, or a few clocks in a country house can be kept uniformly correct by a simple battery. The receivers are placed in circuit with the regulator clocks. The contact is of short duration, being only one-eighth of a second, but the working of all the receivers within the circuit is said to be perfect and their synchronisation absolute. By a special arrangement, the movement of the hands of all the receivers takes place before the complete break of the current in the regulator. The contact is made in the regulator clock every half-minute, the current winding up the main spring simultaneously. From a single regulator clock any number of receiver dials can be worked.

The French Cable Subsidy.—Now that New South Wales and Queensland are being twitted all round with their action in subsidising the first section of the French cable from Queensland to Canada, says the *Pall Mall Gazette*, they try to excuse themselves by declaring that they are committed to nothing beyond supporting the first section of the cable from Australia to New Caledonia. This contention is in no sense borne out by the official documents which embody the exacts terms of the arrangement between the colonies and the cable company. As the Sydney *Daily Telegraph* puts it: "We (New South Wales) are not only saddled with Queensland in a joint guarantee for a period of 30 years, but have been made to agree that this French cable 'shall form part of the main Pacific cable connecting Queensland with Vancouver, San Francisco, or other places in North America as may hereafter be determined!'" Language could not be more definite than this, and the engagements entered into by New South Wales and Queensland will obviously, in spite of their optimistic disclaimers, seriously hamper them in affording assistance to an all-British cable should its construction be decided on, as the result of Mr. Sandford Fleming's visit to Australia.

The Halifax Fire. We stated last week that on the 23rd Nov. a serious fire occurred at the electrical engineering works in Square-road, Halifax. The building was five storeys high. The two upper storeys were tenanted by the Northern Electric Wire and Cable Company, Limited, and there were in these rooms many valuable machines, besides large quantities of wire. The two floors next below were formerly tenanted by Messrs. Blakey, Emmott, and Co., Limited, electrical engineers. A few weeks ago their plant was sold by auction, and the rooms have since been empty. On the first floor Mr. Walter Emmott, electrical engineer, had his business, and his stock comprised lathes, electrical machines, etc. In the cellar the Mutual Electric Light Company, Limited, had their plant for supplying electricity to shops in the town. This plant included five large dynamos and three engines, the whole having been put down at a cost of £3,000. The fire broke out shortly after midnight, and the building was soon burned down. A rough estimate of the damage is £10,000

or £11,000, which is all covered by insurance. The Electric Wire Company are insured in the Royal Exchange and Lancashire Companies, while Mr. Walter Emmott is insured in the Kent Insurance Company. The Electric Supply Company have their plant fully insured in the Scotch Alliance Company. As a result of the fire, the Mutual Electric Light Company are unable to supply light, and tradesmen who had been dependent on this source have been obliged to resort to other means for illuminating their premises.

Electric Lighting in the City.—Colonel Haywood, the engineer and surveyor to the City Commission of Sewers, has recently submitted a report, to which reference was made in a previous issue, showing the failures of the public electric lighting in the City which occurred during the half-year ending October 31, and the occasions on which gas has been used in substitution. He states that the returns of these failures were made by the police. The total number of arc lamps in use up to the present time is 479. The number of gas lamps disused but maintained ready for lighting is 1,219. The total number of failures of the electric lamps during the half-year was 301, each lamp being counted separately nightly. The most serious failure happened on May 7, when 42 electric lamps were not lighted for periods varying from one hour 30 minutes to two hours 34 minutes. On that occasion the gas lamps were lighted. The excuse was a defective switch, the fault in which was not discovered earlier in the day. The majority of the other failures, however, were not in groups or for long periods of time, and if the total number of hours the lamps failed were divided into the total number of hours that the whole of the electric lights were burning during the six months, the percentage of time when the lamps failed was but small. The 479 arc lamps in use nightly cost each £26 per annum, or £12,454 in all. The length of street in which arc lamps are fixed is about 13 miles. The 1,219 gas lamps which are maintained ready for lighting, cost annually about £1,182. The fines for these defects in lighting, as prescribed by the contract with the Commission, has been deducted from the accounts of the electric lighting company.

A Large Mine Pump.—The most striking piece of machinery in the mining exhibit of the General Electric Company at the recent Chicago Exhibition, was a single-reduction electric pump employed to furnish a head of water to a Pelton wheel in the exhibit illustrating the transmission of power by three-phase currents. This pump is triplex double acting, having outside packed plungers, operated by means of cross-heads and connecting-rods, from an extra heavy forged steel crankshaft. It was designed for mine work, and has a capacity of 500 gallons per minute against 650ft. head. The plungers are of bronze, have a diameter of 5⅝in., and are 18in. stroke, and when operating at full capacity require 50 revolutions of the crankshaft per minute, giving a plunger speed of 150ft. The cylinders and valve-chambers are made of composition metal in order to resist the action of bad mine-water. The pump is operated through a single set of gears by a six-pole 75-kilowatt motor, making 275 revolutions per minute. This necessitates a reduction of only five to one at the gears. The design of the pump is, in many respects, novel. The arrangement of the armature shaft, which is prolonged over the top of the pump, brings the motor to one side of the pump instead of in front, as is usually the case. By this means a great saving in space is effected, and this fact is a matter of considerable importance when it is a question of installing pumps in the underground recesses of mines. The pump throughout is solidly, substantially, and extra heavily constructed, and may be run for long periods without cessation at its full rated capacity. An electric pump of similar capacity to this has been for some time past operating successfully in the Calumet and Hecla mine.

Old Students' Association.—The report for the session 1892-93 of the Old Students' Association of the City and Guilds of London Institute has been issued. The report states that during the year the following meetings were held: the annual dinner, a dance, two smoking concerts, addresses by the president (on "Human Dynamics") and by Mr. Clinton T. Dent (on "Mountaineering"), and papers by Messrs. Brew and Ledger ("Central-Station Notes") and Mr. Howard Swan ("The Series Systems of Learning Languages"). The association has sustained great losses during the session in the deaths of Mr. H. C. Saunders, Q.C., and of Mr. Anthony Reckenzaun. The committee are of opinion that, in order to attain a larger measure of success, the association should be so developed that its operations do not conflict with those of other bodies, and that in the future greater prominence should be given to the social aspects of the work. The committee suggest, therefore, that the association should be worked on more distinctly social lines, and that for this purpose meetings for the reading of scientific papers should only be held when matter arises of sufficient importance; that three regular meetings—viz., a dinner, a conversazione, and a smoking concert—be held in each session; and that the subscription be made a nominal one. The committee state that the thanks of the association are due to Mr. Clinton T. Dent and Mr. T. E. Gatehouse for their assistance at the meetings, to those members who have read papers or otherwise helped during the session, and to the authorities at the Central Institution and Finsbury Technical College for the use of the rooms. A general meeting will be held on Tuesday next at 8 p.m. at the Finsbury Technical College, to receive the annual report and balance-sheet and to consider the scheme proposed for the future working of the O.S.A. Mr. Ll. B. Atkinson, the retiring president, will give an address, entitled "A Trip to Chicago."

Technical Education.—On Monday, Lord Derby distributed, at the Crewe Mechanics' Institution, the prizes and certificates awarded upon the results of examinations by the Victoria University, the Science and Art Department, the Union of Lancashire and Cheshire Institutes, the City and Guilds of London Institute, and the Society of Arts. In the course of an address, the Earl of Derby said there were now in science many openings, and many chances were placed in the way of those who desired to apply themselves practically to science, of acquiring that information and teaching upon which alone in these days scientific progress rested. As an instance, he mentioned that it was in comparatively recent years that magnetism and electricity had become subjects of practical study, or formed a part of our daily life. Now there was hardly a square mile of the country which did not owe something to telegraphy. There was not a square yard of the great railway system with which Crewe was connected that could be worked under present conditions without the aid of electricity. Many persons believed, as he did, that we were only at the opening of the dawn of greater progress in that respect. The application of electricity to the transmission of power and its diffusion in small motors were matters which affected our everyday affairs, both in the manufacture and conduct of machinery and in regard to those questions which were pressing themselves to the front nowadays. For his own part he believed that those who now would take up the study of electricity would have hereafter brought before them probably some of the most complex and at the same time the most interesting problems to solve that were to be found in any other branch of science. They had yet

very much to learn, and there were great openings in the future for those of quick brains and ready hands in the department of practical science. It might not be given to everybody in that room to achieve such triumphs in mechanical construction as his friend, Mr. Webb, or his predecessor, Mr. Ramsbottom, won, but still there were many persons in the audience who would yet make their mark and find success by persevering industry, by their skill in science, and by the knowledge which they had gained at that institution.

The Liege-Herstal Electric Tramway.—Some time ago we referred to the opening to traffic of the electric tramway between Liège and Herstal in Belgium, and we now give from *L'Electricien* of the 25th November some particulars concerning this line. The system adopted is the overhead trolley method, the return being formed by the rails and the earth. The generating station contains two multitubular boilers of the de Naeyer type capable of working up to 120lb. pressure, and provided with feed-water heaters and Worthington pumps. The steam is supplied to two engines, each of 60 h.p., running at 130 revolutions a minute. These engines are provided with variable regulators, and have been made by the Société Anonyme "le Phenix" of Ghent. Each engine drives a four-pole dynamo giving 100 amperes at 550 volts when driven at 700 revolutions, and made by the Allgemeine Elektricitäts Gesellschaft of Berlin. The total length of the line, which is single throughout, and provided with three loops for crossings and switches at each terminus, is nearly two miles, and it is of 4ft. gauge. The line has some steep gradients and stiff curves. The rails, which weigh 63lbs. to the yard, are laid on metallic sleepers with the interposition of ballast. As far as the electrical connections between the rails are concerned, two galvanised iron wires, 6mm. diameter, are connected to the rails at intervals of 7ft. by means of pins inserted through the sleepers and the rail. Not content with this arrangement, eight earth-plates have been placed in pits at a depth of 65ft. in the ground. The object of these plates is to equalise the potential of the rail with that of the earth, and to confine any leakage to the lower parts of the soil instead of permitting leakage in the upper part, and therefore into the telephonic system, etc. Notwithstanding these precautions taken to eliminate any disturbing effects in telephone working, troubles have arisen which have attracted the attention of the telegraph and telephone service. A good earth constitutes an excellent condition for the working of a tramway, but the efficacy and the excellence of the methods applied to ensure the return of the current through the earth do not exempt the system from inconveniences inherent to its own constitution. The phenomena observed at Liège furnish another proof of this fact. The overhead conductor is carried on iron standards erected at intervals averaging 108ft.; these standards also support two feeders, one of which is carried one-quarter of the length of the tramway, and the other the remaining three-quarters. These feeders are respectively of 35 square millimetres in section, and 150 mm. The trolley wire is of Montefiore phosphor bronze 7mm. in diameter; it is carried partly on brackets attached to the poles, and is partly supported by steel transverse wires. With regard to the rolling-stock, constructed by the Société Saint-Léonard, of Liège, only one motor is fitted to each car. This type of motor, made by the Compagnie Internationale d'Electricité, of Liège, is of 25 h.p. The armature shaft is prolonged, the prolongation being provided with a pinion gearing into a toothed wheel arranged on the car axle. The speed of the motor is regulated by means of a rheostat connected with two contact squares, upon which pass two brushes in connection with the brushes of the motor. The initiative in this enterprise was taken by the Société des Tramways Liègeois and the Compagnie Internationale d'Electricité.

The Dangerous Working Heat of Mild Steel.—A paper was read last week by Mr. J. Nodder before the North East Coast Institution of Engineers and Shipbuilders on "The Dangerous Working Heat of Mild Steel, and the Effect of Annealing and Air Cooling." The author pointed out that the more general use of Siemens-Martin steel for boiler purposes was perhaps limited by 15 years. The most reliable and satisfactory results from Siemens-Martin mild steel were obtained from material of 26 to 30 tons tensile, and not less than 20 per cent. elongation in 8in., the distinction between high and low tensiles within this limit being a fallacy. Steel of 26 tons tensile or 30 tons tensile could be produced from the same ingot almost at the will of the plate-roller, certainly without any variation of the chemical constituents of the material, and the same failures would be produced by mechanical treatment in steel plates anywhere from 24 tons tensile strain to the square inch to 30 tons per square inch. Basic and Bessemer steels were subject to the same weaknesses, though Bessemer steel developed faults in working out of a fire that made it unsuitable for general boiler work, and its use was very limited. Basic steel, if made on the open-hearth system, gave very similar results to Siemens-Martin steel; but practical experience has not yet developed sufficient confidence in its use as a substitute for Siemens steel in external and internal flanged boiler work. An increased elongation, say, to 25 per cent. in 8in. of steel 30 tons tensile would show greater ductility than 24 tons tensile with only 20 per cent. elongation. This was a point that is generally overlooked, a demand being made for a lower tensile rather than an increased elongation. Similarly, much was made of a "flanging test," but the only reliable test of steel was that obtained by the actual measurement of the force applied and represented by the tons tensile and the percentage of elongation. Bending tests—cold, hot, and quenched—were useful aids, the latter especially, but unless the force used for bending was accurately measured the test could not be tabulated, and was only of service in conjunction with the tensile tests. After referring to tests made years ago, the author stated that experiments conducted at Messrs. John Brown and Co.'s works in 1892 and 1893 would place the dangerous heat near 400deg.; that Siemens or basic steel hammered at that temperature retained all the brittleness resulting from that dangerous heat, even when cold, which did not appear in experiments made in 1881; and that reheating without "work" would restore all the ductility that previously existed. The results of a long series of tests would teach that the heating and reheating of Siemens steel made little or no difference to the structure of the material when cold, providing no work had been put upon it between 400deg. and 600deg., and also that steel might be hammered and bent cold without detriment. Annealing was another of the vexed questions that surrounded steel, and the effect of air cooling had been the basis of much theorising upon the causes of failed furnaces, tube plates, etc. The result of experiments to which he referred proved that air cooling, even under extreme variations of temperature, could make no appreciable difference to this class of material. The same could not be said of water cooling, and a comparison of tests showed a marked change, and an increase of 10 tons per square inch tensile, and a decrease of 51¾ per cent. of elongation, after heating to 1,500deg. and cooling in water at a temperature of 60deg., making the material quite unfit for service without again reheating.

F. J. DOWN.

Mr. F. J. Down, F.C.S., M.I.E.E., was born at Bristol, Somersetshire, and educated at Macclesfield, Sandycroft College, and Wiesbaden. From Sandycroft College, Mr. Down went to Glasgow, and became apprenticed to Messrs. A. and W. Smith, of Cook street, general engineers and boiler makers. After his time was out he went over to Wiesbaden, and there studied physics, chemistry, etc., under Prof. Newbauer at the celebrated laboratory of Prof. Fresenius. On his return to England he at once entered the chemical works belonging to Messrs. Charles Tennant and Co., chemical manufacturers, at Hebburn-on-Tyne, where he remained about five years, and afterwards left there to carry out, on behalf of the Blaydon Chemical Company, first in the laboratory and afterwards on a commercial scale, various new processes being there introduced. From there he came to London, and at the works of the Silicate Paint Company, of Charlton, Kent, introduced the manufacture on a large scale of sulphide of barium, which is principally used for the making of their non-poisonous paints. Being desirous of entering into business in London, through mutual friends he joined Messrs. Laing and Wharton, the accredited agents of the original Swan Company, on Holborn-viaduct, the name of the firm becoming Laing, Wharton, and Down, who, as electric light engineers and contractors, have already successfully carried out a very large number of electric light and power installations. This firm brought from America the Thomson-Houston system of electric lighting, now so largely used by railway companies, central stations, and recently chosen for the large central station for the lighting of the eastern division of the city of London. This system was first introduced into England at the Inventions Exhibition in 1885, where it created great interest, and was exclusively employed in lighting the American Exhibition in 1887, the Italian Exhibition in 1888, and the great Military Exhibition in 1890. Mr. Down has always been a most energetic member of the firm, and has won a wide circle of friends in the industry into which he has thrown his lot.

SOME RECENT DEVELOPMENTS IN ALTERNATING-CURRENT MOTORS.

BY ELIAS E. RIES AND GORDON J. SCOTT.

Among the most interesting and valuable features that characterised the work of the International Electrical Congress recently held in connection with the World's Fair at Chicago, were the remarks made by many of the distinguished delegates present upon the subject of the transmission of alternating currents and the respective merits of single and multiphase motors for power distribution. Although opinions were somewhat divided upon this latter question, it was clearly recognised that the multiphase systems at present available were merely an expedient rendered necessary by the existing state of the art, and that the advent of a simple and efficient self starting single-phase alternating-current motor would at once establish the latter as the standard type for nearly all classes of electrical power distribution.

In the course of some extended experiments made by us upon the subject recently we have discovered and practically demonstrated a number of important facts, which in many respects revolutionise the theories that electricians have heretofore held and have been accustomed to regard as essential principles in the design and construction of alternating current motors. These discoveries, which promise to inaugurate a new departure in alternating motor construction, have shown us that it is not only possible to construct self-starting, non-synchronous, alternating-current motors of any desired power that will run economically on single-phase circuits of any commercial frequency—such, for example, as that in common use for incandescent lighting—but that such motors will be, everything considered, far more efficient, both electrically and mechanically, than the best continuous-current motors yet produced.

The difficulties hitherto encountered in attempts to construct self-starting variable-speed motors intended for operation on ordinary alternating current incandescent lighting circuits, have apparently been of an insurmountable nature. With the exception of the smaller types of motors developing a fraction of a horse power—such as those used for operating small ventilating fans, where economy in the use of current has been considered of minor importance, and in which the self induction in the energising coils and the losses in the magnetic circuit could be kept reasonably small—all attempts to produce efficient motors to operate on a simple two-wire alternating circuit, without the employment of more or less complicated auxiliary starting or lag-changing devices, have thus far failed. Even two-phase and polyphase motors as at present constructed, although self-starting under light loads, require for their efficient operation not only a low frequency that unnecessarily increases the size of the generating, transforming, and motor apparatus, and which renders it in many cases unsuitable for lighting purposes (to say nothing of the greater complexity of the feeding and distributing mains which such a system involves), but owing to the great sacrifice in electrical and mechanical efficiency when their normal speed is departed from, such motors cannot compete with direct-current motors for work where a variable speed with maximum torque is requisite—as, for example, in the case of electric street railways.

Following up our researches in the alternating-motor field, and with the view of producing a motor of simple construction that could be operated on any of the commercial alternating-current circuits now in use with reasonable economy, we built a number of experimental motors of various types and sizes, embodying some of the results of our investigations. These motors have been thoroughly tested in the factory of the Ries Electric Specialty Company at Baltimore, Md., and the results obtained have been so successful that we are now making preparations to build alternating-current motors for commercial uses that in the matter of efficiency, simplicity, weight, adaptability, and general excellence of operation will compare favourably with, if indeed they do not in these respects surpass, all existing types of electric motors.

Believing that the remarkable results we have already obtained will be of general interest at this time, we have thought it advisable to present herewith a photograph of one of the single phase motors built and used by us in some of our experiments, together with such information concerning its operation as we are at liberty to disclose at present.

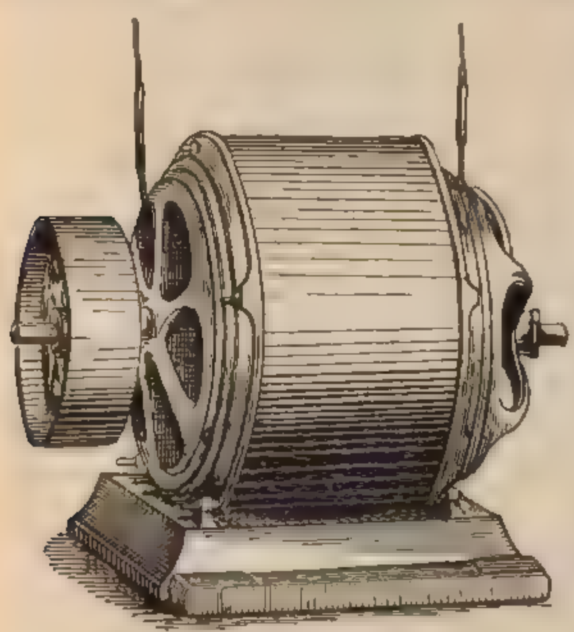
The motor illustrated has a capacity of 1 h.p., and was designed for and tested on an ordinary 50-volt alternating-current incandescent light circuit, having a frequency of 138 complete cycles per second. The most noticeable feature is its extremely small size and weight for a motor of its output and efficiency. The total height of this motor, including base, is 2½in.; the diameter of the motor proper, 9in.; the width of motor, exclusive of end plates containing bearings, 5in.; the total length of armature shaft, 11½in.; while the total weight is but 35lb., of which only 2lb. are copper.

Actual brake measurements were made upon this motor, while the same was running at various speeds, on an ordinary 50-volt incandescent circuit of 138 complete cycles per second. At a speed of 2,000 revolutions per minute, taking 15 amperes of current, the motor developed 26,400 foot pounds, or ·80 h.p., at an electrical efficiency of 90 per cent., the motor remaining perfectly cool after a continuous run of eight hours. With 10 amperes of current the power

developed was 17,850 foot-pounds, or ·54 h.p., with an electrical efficiency of 93 per cent.

On increasing the load on the motor, and thus reducing the speed to about 1,000 revolutions, with the same flow of current, the power developed was substantially the same as before, with very nearly the same efficiency. When the speed was reduced below 600 revolutions, however, the efficiency dropped appreciably, although not enough, even in the case of the present high-speed machine, to detract from its usefulness for continuous and effective work at speeds very much below those hitherto found practicable in direct-current work.

The diameter of the driving pulley is 5in., yet, notwithstanding this, the torque developed by the motor is so great that it starts off promptly under full load. The speed of the motor, as has been fully demonstrated by these tests, is variable within wide limits and without appreciable loss in efficiency—a result that has not heretofore been obtainable either with direct or alternating current motors. Another and most valuable characteristic of one type of the motor under consideration is that with a given flow of current the torque increases up to a certain point as the speed decreases. This peculiarity is likewise entirely new, and of the utmost importance, since it not only provides an exceedingly high starting torque, but enables the motor to develop its maximum power continuously at the highest



Ries and Scott 1-h.p. Single-phase Alternating-current Motor.

possible efficiency and irrespective of the speed at which it may run.

It will at once be apparent that these features render this type of motor particularly applicable for all stationary and railway work where widely-fluctuating loads are encountered, especially so because the principles underlying its construction are such that, unlike direct-current constant-potential motors, it cannot of itself receive more than its maximum normal current under any conditions of use, and thus cannot possibly be burned out or injured by an excessive overload, or by any of the other causes which have proven to be such prolific sources of trouble in the case of continuous-current motors.

Perhaps the most remarkable feature about this machine is the fact that the losses and other difficulties that have heretofore attended the use of comparatively high frequencies for alternating-current motor work, whether single-phase, two phase, or polyphase, have been practically eliminated. Indeed, were it not for this discovery, the results here recorded could never have been obtained. It is probably not too much to say that this achievement, to which we have successfully directed our strongest efforts, will contribute largely to the adoption of higher and more economical frequencies for alternating-current work than those at present in vogue, or, at least, to the maintenance of the highest of the standard periods now in commercial use on lighting circuits, thus deservedly checking the precipitate and ill-advised tendency which is at present more or less prevalent both abroad, where multiphase systems have for some time been extensively used, as well as in this country, to adopt as a standard for general use a current of such a low frequency as would involve not only much larger and more expensive generators, transformers, and motors, but which would prove unsatisfactory and uneconomical to the highest degree for nearly every purpose to which it can be applied.

Since high frequency in alternating-current apparatus is the equivalent to high speed in direct-current apparatus, in being the seat of the direct and counter E.M.F.'s developed, and since it is well known that by increasing the speed of a direct-current armature the output of the machine for a given amount of iron and copper is very much increased, it follows that the higher the frequency that can be used the better the result obtained from an alternating-current motor of a given size and weight. While there are serious mechanical limitations to higher armature speeds than those now in use, there are, so far as the motor is concerned, no longer any restrictions to the use of higher frequencies, since the self-induction and hysteresis, which in all previous types of alternating-current motors have been the principal sources of loss, are now for the first time utilised in our motor and turned to practical account, as shown by the fact that the motor runs perfectly true, despite the small quantity of iron and copper in the machine. Thus on circuits of higher frequency the alternating-current motor will possess not only an enormous advantage over its continuous-current brother, in the matter of safe and economical transmission over long distances of the power that gives it its vitality and scope, but will be far superior to it as a motor by reason of its more simple and compact form and the correspondingly increased amount of the power it is capable of generating per unit of weight under these conditions.

In addition to the experimental motor illustrated herewith, we have built other single-phase motors of larger sizes that are now doing successful work in the factory of the Ries Electric Specialty Company, where they can be seen in operation. Some of these motors are designed for synchronous working and run at a constant speed under varying loads. As in the case of the variable-speed motor, they are self-starting, and run rapidly up to synchronism without the use of a special starting coil or switch, and will automatically regain synchronism should their speed be temporarily reduced below it by reason of a heavy overload.

We are now able to predetermine the characteristics of our motors with as much accuracy as with direct-current machines, and, as already stated, we are rapidly completing the designs for a full line of these motors, ranging all the way from a small-size $\frac{1}{6}$-h.p. alternating-current fan motor to the largest motors that may be required for stationary work. We have now likewise in course of construction a single-phase high-frequency alternating-current railway motor of 40 h.p. capacity, which will have less than one-half the usual weight of direct-current motors, and will embody some novel features peculiar to itself that are likely to have an important bearing upon the future of the electric railway.

To those who have been accustomed to the behaviour of direct or continuous current motors, or to those who have regarded the continuous current as the only practicable and economical one for power purposes, the remarkable performance of this motor and the simple manner in which these results are obtained is little short of marvellous. The comparatively high frequency of the alternating current used, the adaptability of the motor to the ordinary single-phase circuits, the exceedingly small size and weight of the motors compared with direct-current machines of similar capacity, the absolute reliability of their operation, the extremely slight internal losses in the machine, to which their unusually high efficiency is largely due, and the great simplicity of their mechanical and electrical construction—in short, the radical departures made by us in the entire design of these motors, regarding which we hope soon to be able to publish full details, causes these motors to excel in every respect all that has yet been accomplished by the continuous-current motor, and far surpasses in its reality the most sanguine expectations of even the foremost advocates of the transmission of power by alternating currents.

THE USE OF STORAGE BATTERIES IN ELECTRIC GENERATING STATIONS FOR UTILISING AND REGULATING POWER.*

BY C. O. MAILLOUX.

The diffidence with which I entered upon the task of preparing a report on the above subject for this association is sufficiently proven by the fact that I made a couple of unsuccessful attempts to decline the honour. My excuses and objections, however, availed me little with Mr. Longstreet, your honoured chairman, who soon had me enlisted. He doubtless did not realise at the time, and I myself did not realise till some time afterward, what a difficult task he had allotted me, and when I state, with full conviction, as the result of my investigation, that probably no American engineer is competent to do this subject full justice unless he has been able to study it for several months in Europe, where alone the material for its study exists to any extent, Mr. Longstreet may agree with me that he should have selected for this report some European member of the association, if any there be.

From its title the present report may be construed to have for its object to discuss the question whether storage batteries are capable, and to what extent, of rendering practical service in electric generating stations, more especially those used for railway traction; and to bring before the association any facts or data relating to this application of storage batteries that may be of possible utility or assistance to tramway managers or engineers who have already or may have later, in consideration, the said application as an adjunct to a generating plant.

The question is not without some importance at the present time when power stations are multiplying and growing so fast as in this country, because this question is one that has an important bearing on the design of the station, since, if this use of storage batteries is really feasible and practicable, in the full commercial sense, its utilisation with a view to securing the full measure of its benefits and advantages would, in many cases, involve somewhat radical changes in the arrangement of the power station, and possibly even in the details of its operation. In Europe the use of storage batteries in central stations has unquestionably made great progress during the last three years, and has actually succeeded in commanding the respect, if not in entirely overcoming the scepticism, of electrical engineers generally. The irregularities of load on power circuits, especially for electric traction purposes, are the bane of the electric railway engineer; and they are too well known and understood to require further mention now, except to classify them; for in reality there are two kinds, which must be carefully distinguished from each other, almost as if they constituted distinct diseases, so to speak, requiring different treatment, even though they may appear together in the same case. We must, therefore, distinguish between "variations" and "fluctuations" of load. I would use the term variation to designate the effect caused on the station plant by putting on or taking off a certain number of cars, and the term fluctuation to designate those incessant and erratic ebbs and flows of current which are so familiar to us all, due to the starting and stopping of cars, changes of speed, grades, etc. The variations of load are defined as changes in mean or average rate of production for a given period of time; the fluctuations of load are defined as changes in rate of production from one instant to another. The distinction between the two will be more readily understood by reference to the accompanying load diagrams.

Fig. 1 shows the fluctuations in an electric tramway. Figs. 2 and 3 show the load curve in an incandescent lighting station.

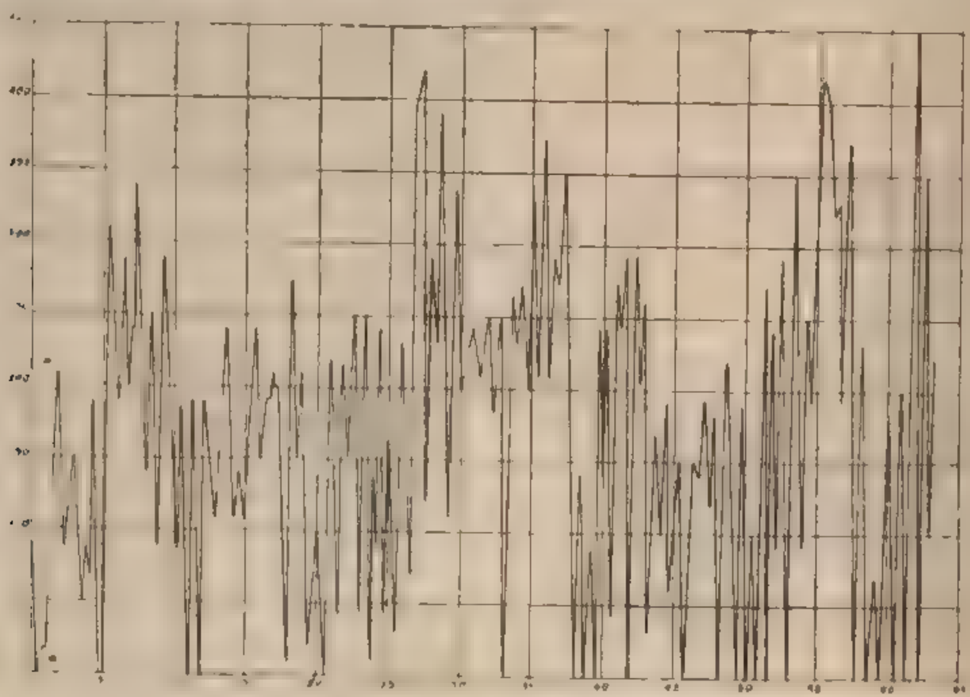


FIG. 1.

Taking the lighting station diagram in Fig. 3, which more nearly represents the usual condition of affairs in lighting stations, it is seen that the momentary irregularities (or fluctuations) are trivial in comparison with the changes (variations) of load from hour to hour, or from one part of the day to another. In the railway plant load diagram we observe a series of ups and downs following each other more or less irregularly every few minutes along the whole day. These seem like fluctuations as compared with the irregularities in Fig. 3. The term fluctuation should, in my opinion, include both the "waves" and the "sub-waves," while the term variation should be restricted to the "billows." It is proper to note that the waves and sub-waves above mentioned are relatively more numerous and marked in smaller than in larger railway power plants. The greater the number of motors supplied from a given source the less likelihood is there of the load being thrown on or off in such large proportions. The load then "averages itself," to use a current expression. Thus, where the number of motor cars represented is large (about 140), the load from 7 a.m. to 9 p.m. oscillates most of the time between 1,000 h.p. and 1,400 h.p., or 20 per cent. above and 15 per cent. below 1,170, which is the mean power rate for the whole day's run, excepting about 6 p.m., where a "wave" begins, lasting a couple of hours, during which the load reaches higher points, in some cases

* Abstract of a report presented to the Street Railway Association, America.

up to 1,750 h.p., or about 50 per cent. more than the mean power for the entire day's run.

Where the number of cars was less than 15, the load ranged at different times between 80 h.p., or about 50 per cent. below, to 380 h.p., or over 100 per cent. above the mean load (about 170 h.p.). The cases are numerous where the load falls down to zero, or runs up to two or three times the average load, in the course of a few minutes.

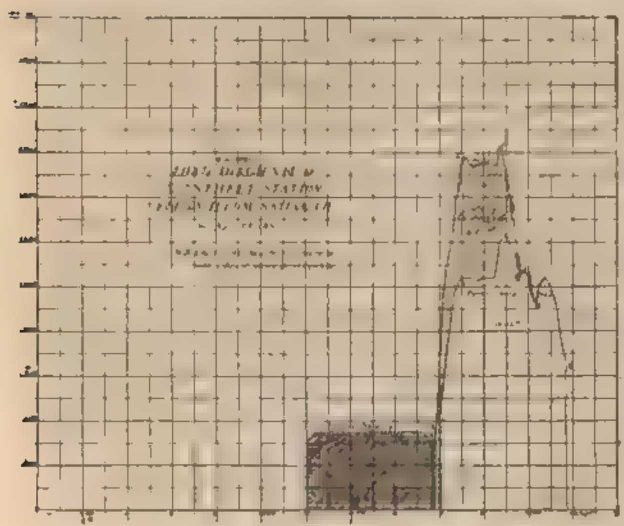


Fig. 2.

These fluctuations cost the railway companies money in three ways: First, because they involve the use of generating machinery of greater capacity than would be required if the machinery were operated at a constant uniform load; second, because the depreciation is greater; third, because the efficiency of the machinery is lower. The first two points are well understood. The third requires a slight analysis. The use of engines and dynamos greater than would be required for the mean load increases the percentage of energy spent in the engine and dynamo to overcome friction, and also to energise the field magnets as the friction load and magnetising energy (neglecting hysteresis and Foucault currents) must of necessity increase

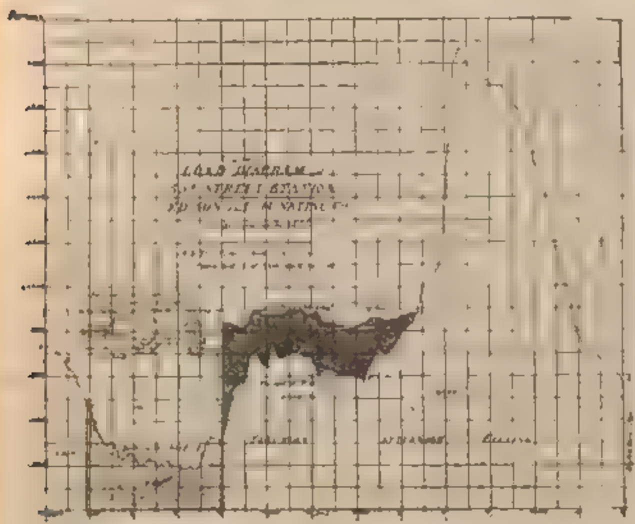


Fig. 3.

with the size of engine and dynamo. By courtesy of Mr. W. S. Barstow, superintendent of the Brooklyn (N.Y.) Edison Illuminating Company, I am enabled to publish (Fig. 4) two curves, A B, showing the percentage of the total indicated horse-power which can be obtained at the dynamo brushes under different loads. Curve A shows the performance of a vertical engine directly connected to a pair of multipolar (100-kilowatt) dynamos; while Curve B shows the performance of a high-speed engine belted to two Edison (70-kilowatt) generators; both engines being compounded and tested as nearly as possible under identical conditions. These curves show that by the time the load has fallen 40 per cent. the efficiency drops very rapidly.

Now, considering a little more closely the engine itself, several authorities have called attention to the extreme variations in steam consumption per indicated horse-power at various percentages of load, which is the real measure of the engine efficiency proper. Cases are not rare where the use of engines too large, but rendered necessary owing to the severe fluctuations to be compassed, have consumed from 10 to 15 per cent. more steam than they would at normal constant load. The total loss, of course, includes the loss in the engine cylinder as well as that due to mere friction. If the steam consumption is, say, 20 per cent. greater than it should be per average indicated horse-power, and if the engine and dynamo utilise 15 per cent. less of the indicated power than they would if of more suitable size and running under better conditions, the net efficiency will be the product of these two factors, or we might say in that case that only about seven-tenths of the steam is utilised. This means that if the same steam could be properly utilised it would do some 40 per cent. more work.

It is for the purpose of better utilising and economising this power that the storage battery is proposed to be used, by taking advantage of its property of being able to "give and take" energy, and thus keep the load balanced and equalised at all times. The principle of its action is that it can be made to absorb energy from the circuit (or the

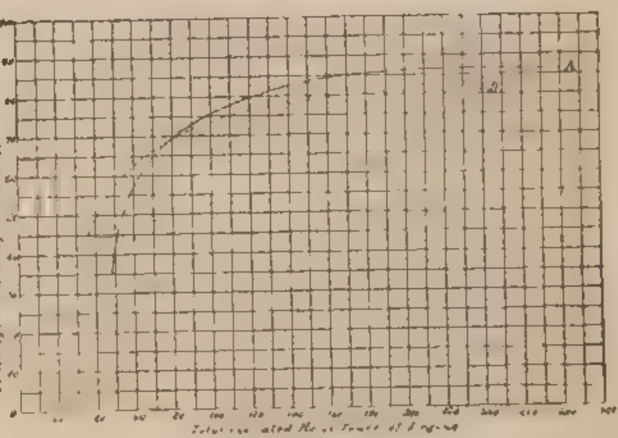


Fig. 4.

dynamos) or give it back in any desired amount, so that absolute control may be had of the total load imposed on the generating machinery independently of the rate at which the energy is consumed.

The use which has already been made of the storage battery for regulating the load in the central stations for electric lighting service is quite extended. It is thought that a brief reference to some of them will be of interest and utility.

By courtesy of R. R. Bowker, vice-president and manager of the Edison Illuminating Company, of New York, and with the kind assistance of William L. Pakenham, of the Crompton-Howell Electric Storage Company, Limited, of London, your committee is enabled to reproduce two interesting curves, showing the performance of a Crompton-Howell storage battery (140 cells, 51 plate elements) which is in use at the Edison Illuminating Company's Fifty-third-street station. This case is detailed first—although it might properly come last—because these very curves will serve to make the function of the storage battery more evident and intelligible. Some explanations should be made regarding the conditions of the case. This (Fifty-third-street) station is one of the supplemental provisional stations, as it were, the company has built in various parts of the city to help its larger station (Thirty-ninth-street, etc.) in supplying the rapidly increasing demand for current. These stations, at first comparatively small in capacity, gradually develop, and eventually become large stations when the patronage justifies. Their chief function is to relieve the other stations at the hours of heavy load, by delivering into the mains a certain amount of current

TABLE A.

Location of station.	Actual capacity in lamps.	Rate. Delivery capacity in kilowatts.		Quantity. Average daily output in kilowatt hours.		Station load factor.	Battery factors.		Dynamo hours run per 24.	Remarks.
		Dynamos.	Battery.	Station.	Battery.		Rate or delivery.	Quantity or output		
Bremen	5,000	360	—	—	—	—	—	—	—	Battery runs 18 hours without supervision.
Hamburg	9,000	737	165	—	—	—	—	—	6	
Barmen	4,000	188	193	—	—	—	—	—	—	
Dusseldorf......	6,000	105	146	—	—	—	—	—	—	In three sub-stations.
Dessau	2,000	108	—	—	187	—	—	52	—	Gas engine.
Gavelsberg ...	2,000	80	33·6	—	—		—	—	10	
Gablonz	1,500	60	23	—	—	—	—	—	—	
Dundee	—	438	22	—	—	—	—	—	—	
Hull	—	113	22	—	132	—	—	—	—	
Hanover... . ..	14,000	840	87	974	425	·479	·104	·438	6 to 8	Battery runs 16 to 18 hours.

that would otherwise have to come, and at greater loss or "drop" from one or another of the stations connecting with the network of mains. Hence, the load may be varied, more or less arbitrarily, at these stations, according to the proportion of load that the larger stations are desired or able to carry. Telephonic or telegraphic connection serves to keep the various stations informed of the conditions at the others.

The storage battery, like the station itself, was installed provisionally and by way of experiment, as it were, without paying very strict attention to the size, capacity, or other conditions necessary to obtain the best results.

The battery is installed on the second floor above the engine and dynamo room, and consists of 140 cells each of about 1,000 ampere-hours capacity, weighing some 750lb., and of about 48in. in length, 21in. in width, and 15in. in length.

The battery has a normal discharge rate of about 200 amperes, but can be discharged, if necessary, at 500 amperes. The two curves show different applications of the battery. The first curve, Fig. 2, shows the station record for April 22, 1893. The station was then running only 12 hours per day, or from noon to midnight. The total load of all the stations being light in the afternoon, the larger stations could easily take care of it; hence the only station load from 12 to 5.45 p.m. was that required to produce only the charging current for the batteries. The plant was running at perfectly constant load, as shown by the straight line, *a b*. The lightly-shaded area below this line represents the current (ampere-hours) put into the battery. By 6 p.m., both the station machinery and the battery were delivering current into the mains. The curve *b d e f g* shows the total current. The curve *c h j k g* shows the amount delivered by the dynamos direct; the rest, or the difference represented by the relative heights of the two curves at any two points (say, *h* and *d*), was supplied from the battery. The heavily-shaded area between the two curves represents the amount of current put in by the battery. Calculation shows that the battery furnished about 23·2 per cent. of the total energy delivered to the mains. The maximum rate of discharge attained by the battery was about 270 amperes. Thus, in this case, we have an example of a battery which is used for the purpose, first, of giving a load to station machinery that would otherwise be idle; second, utilising the stored energy to increase the rate of output of the station at the time of heavy load, which would otherwise necessitate greater dynamo capacity. In the second curve, Fig. 3, five months later, the conditions have been changed. In the first place, the station output has increased greatly, being now about 2·9 times greater, and it is also continuous—*i.e.*, instead of delivering current into the mains only from 6 to 11.45 p.m., as in the first case, the current is now delivered continuously at varying rates represented by the curve *a b c c′ c″ e f g*. The station now runs from 8 a.m. one day to about 2 a.m. the next day, or 18 hours. When it starts at 8 a.m. it carries a twofold load: first, the regular load allotted to this station shown by the curve *c c′ c″ e*; and second, in addition, the load represented by the curve *d d′ d″ e*, which is the current absorbed by the batteries in charging. It is to be noted that the total load is much more uniform than if the station were feeding into the mains alone, for the extremes of current fluctuations shown by the curve *d d′ d″ e* represent a total variation of only 80 amperes on an average load of 850, or less than 9½ per cent.

I have been informed within the last few days by Mr. Pakenham that the battery is now being made to play an additional part of some interest. The maximum load, *f*, has increased to such a point that the station plant is no longer adequate; and consequently the battery is put on to "cap" the summit of the load and supply the excess of current required above the capacity of the dynamos. When the load begins to fall off (about midnight) a part of the plant is shut down; but since the load is still too heavy for the other dynamos, the batteries again serve to supply the excess (from *g* to *h*).

There is only one other case in this country—namely, the Edison station at Germantown, Pa.—where storage batteries are used as load equalisers. The total capacity there is of about 1,000 ampere-hours, made up of several series of small cells connected in multiple. The battery is charged during the six or seven early morning hours when the outside load is very light. It stands idle during the heavy load in the evening, and is discharged to carry the load after the plant shuts down. In this case the battery saves the expense of running the plant during the period of small load. Additional capacity is contemplated by the company, and will probably be put in this winter.

A large battery is being installed at the central Edison station in Boston. This battery, of German manufacture (Tudor), will be by far the largest in this country, the cells being over twice the size and capacity of the battery of those in the Fifty-third-street (New York) station referred to above. Its adoption was decided upon after a special study made of the use of storage batteries in European central stations by C. L. Edgar, the superintendent of the company. The Brooklyn (N.Y.) Edison station has also in contemplation the use of a similar battery.

It is in Europe, however, that the use of the storage battery in central stations has made the most headway.

In the city of London alone there are no less than eight stations supplying current for lighting in which storage batteries are depended upon for part or the whole of the load carried. The aggregate actual capacity of these stations is some 200,000 lights (16 c.p.). In many cases the batteries are not located in the generating station, but at sub-stations suitably located with reference to the consumers. The charging current is sent to the batteries at high potential, several sub-stations being joined in series for the purpose of charging.

In Paris there are some 20 or 30 such sub-stations located in various parts of one section of the city, and all charged from the same central station.

In the "Edison section" of the city an interesting application is made of a large (2,800 ampere-hours) battery, which is located at a point somewhat distant from the central station and connected with the mains from which it is charged at those hours when the load is light, by

taking current from the mains themselves, the potential being regulated by means of a continuous-current transformer. In this way a considerable amount of energy can be sent at a low rate, and, therefore, at small loss or drop of potential. This energy is used for maintaining the pressure in that portion of the mains, and for delivering a certain amount of current which would otherwise have to come from the station over heavily-loaded feeders (in the busy hours), and at greater loss of potential. Thus the battery, in this case, saves the cost of larger feeders, while it also furnishes a load for the hours of small load.

This plan suggests itself as of possible service in electric railway systems covering a large area of territory all fed from a single central station. The batteries could be located at distant points, or at such points as would give the best distribution of current to the trolley lines with the least expensive linework. The station machinery would then virtually work at constant load to feed the batteries, which latter would supply the power needed for the car motors. In this way, not only would an economy in the cost of conductors be effected, but there would be more uniformity of potential all over the system.

Table A gives some additional stations where storage batteries are used, with various data relating to them.

As regards the batteries used, the author stated that the principal object to be aimed at was long life and high efficiency even at the expense of increased first cost. The Planté process of formation and its modifications would seem to have proven itself superior to the pasting or Faure process, if one can make a criterion of the fact that at least nine-tenths of the aggregate of the central-station batteries used is of the Planté type, or some modification thereof. The Planté batteries are conceded to be, usually, of lower capacity per pound; but, on the other hand, they have the advantage of being able to carry heavier rates of charge or discharge.

There is probably no storage battery on the market of American manufacture having as much capacity as 500 ampere-hours. In Europe they can be procured up to 5,000 ampere-hours capacity. A cell of the latter capacity, weighing complete some 4,750lb., size about 36in. × 39in., height about 40in., gives an idea of the scale on which the use of storage batteries in European central stations is carried on. It may be added that a further idea of the scale of operation is obtained by examining the plans of central stations, such as that of Hanover, where a separate building with four floors about 70ft. by 35ft. is reserved for the storage batteries.

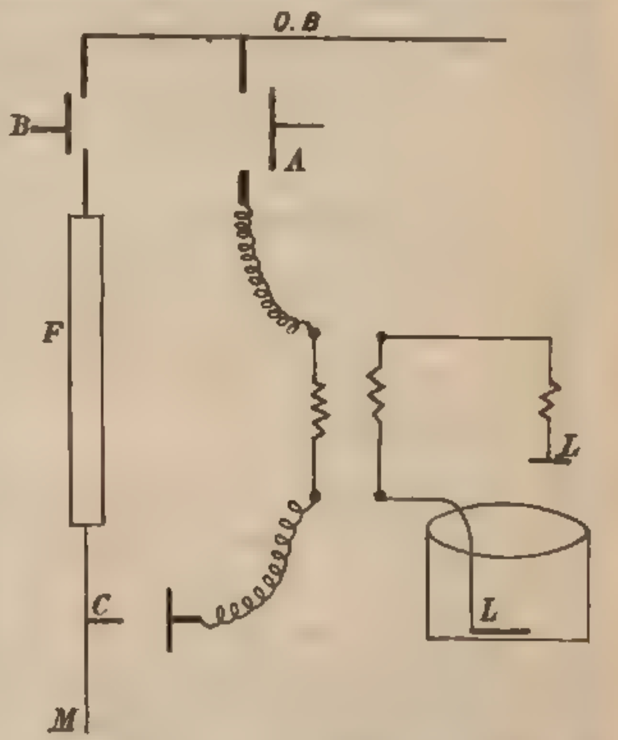
The author also referred to a number of curves showing how the capacity and efficiency of the battery varied with the rate of discharge. To illustrate by an example from actual practice he cites the station at Lyons, France, where the watt efficiency for one month averaged 85 per cent.; at Hanover, 78·4 per cent. for the entire year; at Dessau, 78 per cent.; in the Fifty-third street, New York, Edison station, 85 per cent.—the figures guaranteed by the makers, the Crompton-Howell Company. As regards the first cost of storage batteries the author found it difficult to obtain exact information. He gives a curve showing the variation in cost with increased size for the Crompton-Howell cells. The Electric Storage Battery Company, of Philadelphia, which is about to put on the market some large central-station cells (up to four kilowatt-hours) of a type already in extensive use in France, expects to reduce the cost to 25dol. f.o.b. per kilowatt-hour capacity. The total cost, erected, would be from 30dol. to 35dol., according to distance, etc. The cost of imported batteries, erected, would probably range, according to size, from 40dol. to 65dol. at the present time.

The maintenance is generally guaranteed by the manufacturer for a fixed annual percentage. At first this percentage was as high as 10 per cent. It was found, however, as the result of improvements that the percentage could be reduced safely. The present ruling cost of maintenance is about 5 per cent per annum for a 10-year guarantee. In every case it is stipulated that the battery will be put in as good condition at the end of the 10 years as when first installed.

The author has noted in every case investigated a scrupulous attention to details large and small of the installation of the batteries, and of their care and treatment, which contrasts greatly with the way storage battery installations have been usually treated in this country. This may, and doubtless does, account in part for the difference in results obtained. The information gathered on this point from all sources seem to warrant the conclusion that storage batteries require attention, not necessarily extensive or expensive, but regulated or systematic attention.

PUTTING ON TRUNK MAINS GRADUALLY.

In the brief report in our last issue of Prof. Fleming's speech at the Institution of Civil Engineers, we could only briefly refer to the method adopted at Deptford for turning the current on and off the mains. The method will be better understood from the accompanying diagram. It was first suggested, we believe, by Mr. Partridge, one of the staff at Deptford, and was successfully tested on 2,500 and 5,000 volt circuits before being discussed with Prof. Fleming.



The operation is as follows: Complete the primary circuit of a transformer in series with any main off the 10,000-volt omnibus bar by the plugs, A and C; lower the movable lead plate (shown by the top, L, in the diagram) into a tub of water gradually. As it approaches another fixed lead plate, L, in the water, it will short-circuit the secondary coil of the transformer. When the secondary is thus short-circuited, the plug, B, is put on which connects the trunk main straight through from the omnibus bar. The plugs A and C are then removed, and the movable lead disc pulled up for future use. For taking off the trunk mains the operation is reversed—viz., the movable lead plate is lowered to make contact with the fixed lead plate in the tub, short-circuiting the secondary coil of the transformer, the plugs A and C are put in, and B is taken off. The movable disc of lead is slowly pulled up out of the water and the plug A taken off, finishing the operation. The water-cask used at Deptford is an ordinary 40-gallon cask, and is filled with water to within some 3in. of the top. In the diagram, O B represents the 10,000-volt omnibus bar; F, the main fuse; M, the main to London; A, B, and C, plugs to make or break contact as described.

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A THREE-YEARS' SYSTEM.

Although the progress of electric lighting may be said to have been rapid, it might progress at a much greater rate if there were not certain initial costs to contend against. It was introduced as a luxury, succeeded as a luxury, and, like all luxuries, permeated downwards. Only a certain number of householders can contemplate without a pang the throwing aside of costly fittings and the purchase of new fittings to suit another illuminant. As we have often pointed out, the initial cost of the electric light is not only its own cost but the cost of the discarded gas fittings also. Of course, this does not hold when there are no gas fittings in existence, as in new houses. We hold—and our views are upheld by many householders—that the initial cost of, say, £100 to fix up the lamps is a great deterrent, and many hold aloof because of it. These people would gladly pay a moderate sum per quarter for a definite period, and could afford to do so when they cannot afford to pay a lump sum down. The dwellers in the smaller houses are usually less able to pay large sums than those living in large houses. Yet we feel quite sure that the addition of a number of small houses to the light load curve would assist very largely in levelling the curve. The number of lights on and off in the smaller houses is far more constant than in the larger, and, therefore, the demand would be more regular. It is well known that we have never gone into ecstasies over alternate-current distribution, and the more we look forward to general lighting the more clearly it seems that such a system has limits. Whatever may be said to the contrary, it will become more and more necessary to have a reserve in battery power rather than in dynamo power. At present the light is used by the wealthier classes, and the load is very irregular—the maximum being required for a very short time. Now, we contemplate lamps in a large number of small houses, where at the outside not more than a score of lamps would be wired, and where about four lamps would be in constant use from the time of lighting up to bedtime. These lamps would be required on an average all through the winter months for four to five hours in the evening, and half of them for an hour in the morning. The addition of a large number of such houses to the station supply would not get rid of the load-curve peaks, but would level up the other part of the curve. We think that the demand for the peaks must, sooner or later, be supplied by means of batteries. But to return to our immediate subject. Assume that the wiring of twenty lamps costs from two pounds to two pounds ten shillings per lamp—say, fifty pounds—a sum not worth a moment's consideration to many people, but one that cannot be entertained by others; yet the householder would very likely be ready to pay five pounds a quarter for three years for his fittings, or in many cases would pay the equivalent of a year's instalment down and the remainder in equal sums quarterly. There is any amount of money at the present moment in want of employment. Men are afraid to invest in the channels usually open, hence we are under the impression that a com-

pany founded for the express purpose of fitting-up houses in the manner indicated would probably get all the capital necessary. Of course, any fooling with promoters' and founders' shares would be absolutely fatal to success. It is probable, too, that in another direction an immense business could be done. We refer to motors, but this is too large a subject for us to consider at present. With regard to fittings, it has been suggested that the householder might leave without paying. Surely in that case the agreement would be so worded that the fittings remain the property of the company, and in the vast majority of cases the new tenant would undoubtedly take over the fittings under agreement, and would be glad to do so, because if the original tenant had paid any part of the price, the company would probably agree that when the balance had been paid the fittings would become the property of the tenant in possession. The suggestion has been made before, and, unless we are mistaken, was not long since in a fair way to be carried out—only the unforeseen occurred. Why do not some of the prominent members of the profession combine and set the necessary machinery in motion?

REVIEWS.

First Principles of Electrical Engineering. By C. H. W. BIGGS. London: Biggs and Co., Salisbury-court, E.C. Second edition.

The appearance of a new edition of any work is a matter upon which the reviewer can safely congratulate both author and public, inasmuch as it may be taken not only as proof of appreciation on the part of the latter, but as affording the former a sometimes welcome opportunity of profiting by the superior wisdom of others. In fact, it not unfrequently happens that in a second edition a good deal of the critic is bound up with the author. In this case it is not so, but those who are personally acquainted with the editor of the *Electrical Engineer* will no doubt admit that this exception to the rule is only what was to be expected.

In its revised and larger form, however, "First Principles" is undeniably a very useful book. The want of a work of a thoroughly practical character, written in simple language and giving the right information in a clear and concise way, has long been felt by the young engineer, to whom text-books are well nigh useless by reason of their superabundant technicalities and excessive range of subject. In "First Principles" the author may be said to have drawn a distinction between the electrical engineer and the electrician. He does not attempt to deal with telegraphy, telephony, or the more abstruse theories which govern the measurement and manipulation of weak currents. These, indeed, are subjects which could not well enter into a work intended solely for "engineers." By confining himself strictly to those laws and theories which apply to lighting and the transmission of power, the author has avoided much that might have been considered superfluous, and has at the same time been able to devote ample space to questions of undoubted interest and importance.

In one way the book is unsatisfactory. The chapter on "Distribution," for instance, is surprisingly brief, and secondary batteries are dismissed with a terseness which may be due to a fine contempt or, as the reader chooses, to the exigencies of space. These, however, are faults which may, and no doubt will, be corrected in a third edition.

Very interesting and almost original are the sections on the "Magnetic Circuit" and the "Interaction of Circuits." The author ascribes the earliest application of Ohm's law to the inductive "circuit" to F. C. Webb, and complains that while Ohm is immortalised no one ever hears of Webb. But he is quite wrong. Webb undoubtedly showed—some 30 or so years ago—that Ohm's law applied to the inductive circuit, but in this Gaugain anticipated him, and at a still more remote period—during the nineties of the last century—Walker made frequent reference to the "magnetic circuit," and in the published volume of his lectures will be found some excellent illustrations of lines of force, shown by the now familiar iron filings. Still, the theory is to all intents and purposes new. Few of the younger generation have heard of Walker, Gaugain, and Webb, and I am not disposed to deprive Mr. Biggs of his share of the credit, more especially as he can fairly claim to have invented the expression "loops of force"—an expression more descriptive and more correct than "lines of force"—and to have been the first to suggest the adoption of the line of force as a unit. These, however, are matters which are chiefly controversial, although they should claim the attention of every student who does not wish to be under the disadvantage of having to unlearn at some future time. There are not many things of greater importance to the engineer, old or young, than a proper understanding of the magnetic circuit, and it cannot be truthfully said that at the present moment our knowledge of the subject is exhaustive.

"First Principles" is nominally divided into six chapters, but the book is really contained in three—*i.e.*, "The Conductive Circuit," "How to Produce Electrical Pressure," and "Dynamos." The former includes an explanation of the phenomena which occur upon bringing circuits within the sphere of influence of each other, which is extremely valuable, and in Chapter III. the section on Electrographics is one of the main features of the work. I cannot help thinking that in the chapter on Dynamos, etc., more space might have been given to transformers and motors, but no doubt it is difficult within the compass of a two-and-sixpenny volume to amplify every detail.

THE ELECTROMAGNET.

Prof. S. P. Thompson has written a most admirable treatise on this subject. The author is evidently desirous of producing *the* classic on the subject, and in what he has done shows an immense amount of painstaking research. In view of future editions we may venture to suggest certain considerations and possible emendations.

On page 58 he says: "In former days magnetism was regarded as a surface phenomenon, resident (as an invisible fluid or fluids) upon these polar parts of the surface."

Unfortunately, our library is a comparatively poor one, hence Prof. Thompson may be able to prove all he says. Yet as far back as 1799, or close on a hundred years ago, the contrary to what he says was taught. If by his "former days" he means days more than a century ago, we give in, for we have no means of disputing the assertion.

In Walker's lectures, published in 1799, page 44, we read: "Is not this appearance favourable to the idea of an effluvium, flowing all round the magnet from one end to the other, and *having a circulation through* it." (The italics are ours.) Mr. Walker was led to this conclusion because of the behaviour of iron filings, and his diagrams are almost as complete and satisfactory as are those of Prof. Thompson himself.

As for the term "magnetic circuit," it is used again and again throughout the lecture.

Page 45: "A magnetic circuit is formed."

Page 45: "So soon as the bar *q* has completed the circuit."

We cannot find much clearer language in the most modern books, and if we are to give credit to anybody for opposing the doctrine of "surface phenomena," surely such an author as the one quoted deserves credit; but Walker's name does not appear in the index of Prof. Thompson's book. If any open-minded man will read the whole of Mr. Walker's lecture, he will probably be astounded at the knowledge displayed therein—remembering that "galvanic electricity" was then a thing of the future, as was the "electromagnet."

Coming to a later time—after Ohm had written his

paper and Sturgeon made his electromagnet—though Ohm's work does not seem to be known to the writer we are about to quote, that writer only needed it to have forestalled later-day writers in applying it to magnetism.

Dr. Roget, in his essay on magnetism, published in 1831, writes: "Thus it appears that the theory of magnetic attractions and repulsions is reduced to the same principles, *and leads to the same formulæ*, as the theory of electric forces in conducting bodies." (The italics are again ours.)

Is it not singular to find Roget's name wanting in Prof. Thompson's book? Surely, too, Roget and others before him no doubt knew about the magnet without poles—in the shape of a ring. If this is doubted, refer to paragraph 291, page 90, of Roget's "Electromagnetism." There will be found an illustration of a complete ring. But, as we say, "former days" is so indefinite that they may mean before 1831 or 1799. There are other historical statements which seem worthy of modification, but we shall have said enough if by these remarks we lead the author to generalise more or specialise more exactly.

LOAD FACTORS OF ELECTRIC TRAMWAY PLANTS.

BY FRANK B. LEA.

(Concluded from page 495.)

The extensive momentary variations (or "waves," as they have been called) in the load of an ordinary street tramway system are found to range almost inversely with the size of the system and the number of cars at work, or the regularity with which the latter are spread over the system. On a line where only a few cars are at work, the discrepancy between average and maximum horse power or output is naturally greatest; and here the latter may reach as high a proportion as three or four times the average. Where the output, on the other hand, runs into hundreds of horse power, the ratio is much less and tends to approach unity under favourable conditions.

In such a case the chief concern of the engineer is to provide means for "evening-up" the load curves showing the "tidal" variations—that is, to employ accumulators or other source of reserve power stored up during the hours of small load for use when the time of extra demand comes on—the generating plant (of a total capacity equal to but not more than the average) being kept going all the time at full load.

There is no need in this place to enter upon the much-discussed—and still unsettled—question as to the efficiency of accumulators; the report by Mr. Mailloux (already alluded to) touches upon this topic very fully, and should be referred to for a summary of our present knowledge and information. It is, however, worth while comparing the two methods, first, driving direct, with engines running for the greater part of the time at little more than half load, and second, employing accumulators with smaller engines at full load, from the standpoint of steam consumption, in order to show what saving, if any, can be effected in the coal bill.

In the case assumed, where the maximum output was 400 h.p., whilst the average only reached about 250 h.p., we may take for good compound condensing engines working at a little more than half load a consumption of steam per horse power hour equal to about 23lb., so that for 18 hours the total would reach 103,500lb. With batteries, we should have smaller engines of the same type running continuously at full load on a consumption of, say, 17lb. per horse-power hour, supplying the line direct for 11 hours with the full 250 h.p., and for the rest of the day affording about 100 h.p. for seven hours during the times of light load, with a balance of 150 h.p. for seven hours (or even assuming more than this, say 200 h.p. for nine hours so as to allow for recharging with an efficiency of 75 per cent. for the accumulator) as reserve power stored in the accumulator, sufficient for the "tidal" peaks.

This gives a total of about 89,250lb.—considerably less than with the larger engines running at half load; but of course other items besides the fuel account must be considered. The capital cost of regulating batteries of this type is very considerable, whilst the interest and depreciation may more than cover the saving in steam. Moreover, there is the serious difficulty arising from the difference in voltage between the charging and discharging battery currents; so that unless we employ accumulators of a much larger size than is absolutely necessary, the line voltage must vary in accordance, perhaps even more than when running direct.

These considerations will have different values in every line dealt with, and ought to receive separate attention, so that after duly weighing them a decision may be come to regarding the advisable use—or otherwise—of accumulators as appliances for regulating the load upon a tramway generating plant.

At present, all that can be said is that the plan of thus employing accumulators offers advantages of slightly greater extent than those given by a direct supply, even taking into account the additional complication of battery work and appliances. When we come to the question of levelling the "waves," however—as well as the "tides"—the conditions to be met are somewhat different, and require a separate treatment. In the early stages of electric traction, whilst its history is being made, we cannot, of course, expect to find it employed on so large a scale as future developments may show to be advantageous; and, therefore, the tramway engineer has to calculate a reserve not only for the fixed peaks in his load curve, but also for the rapid variations that come and go almost instantaneously throughout the day, and which are usually the greatest in a small system.

Although accumulators have long been used for the purpose of steadying the load from central stations for electric lighting (where, as already shown, the "wave" variations are comparatively slight compared with those occurring in an electric tramway station), yet it is doubtful whether they will act quite so satisfactorily in levelling "waves" that vary from 50 per cent. below to 100 per cent. above the normal average in as brief an interval as two minutes. Certainly, the writer knows of no instance where this has been done for any length of time.

The suggestion, first made, I think, by Mr. Kapp, that separate "flywheel motors" should be employed at different points upon an extensive system to act as reserves of power for very short intervals of time, is of a much more practical nature, and without any doubt will prove worthy of adoption when electric tramway engineers have learnt to consider every detail of their plant, however trifling.

So far as the "wave" variations are concerned in the line assumed for consideration, it may be necessary to allow for a difference of, say, 150 h.p. in the output in the space of a minute or two, and it is for coping with such differences where the load comes on and off instantaneously—that a heavy flywheel is most suitable. If the tramway system be concentrated rather than scattered, there is no reason why this provision for reserve power should not be made in the generating station, where it is an easy matter to arrange for a heavy pulley on the engine or dynamo shaft.

Where, on the other hand, the line is of considerable length and spread out somewhat widely, separate sub-stations may be advantageously provided, containing each a suitably wound motor operated from the line mains, and serving to rotate a flywheel of sufficient capacity for the extra demands on that section. The waste of power in such an arrangement is trifling, and little or no attention becomes necessary as compared at least with battery sub-stations.

The energy afforded by a flywheel employed in this manner is, of course, dependent upon several factors—weight, speed, and diameter—and to give the amount of reserve power necessary upon our typical line—viz., 150 h.p.—it would be sufficient to provide a couple of flywheels, each, say, of 6ft. mean diameter, with a weight of four tons, and allowing the speed to drop from 700 revolutions to 500 per minute. From 80 h.p. to 90 h.p. might thus be obtained in each wheel, or enough to carry the load safely over the peaks representing the positive amplitudes of the load waves, taking the line of average output as a base.

When the levelling process can be carried on at the generating station, it becomes a simple matter to increase

the storage capacity of the flywheels usually employed with the prime movers, of whatever type the latter may be. On the City and South London line, for instance, the engine flywheels, or driving pulleys, have a diameter of 14ft. and a weight of 14 tons, which, moving at a speed of 100 revolutions per minute, serve to store up some 2,500,000 foot-pounds of energy—an amount which ought to be sufficient to maintain fairly constant speed over a range of 80 h.p. variation in a single minute of time, even with slow-running engines.

With prime movers coupled direct to the generating dynamos—such as are now most generally employed—the flywheels may similarly act as energy stores; perhaps, indeed, even better, because the slip and other losses of belting are avoided altogether, instead of being increased; by reducing the diameters in proportion as the engine axle speed increases, suitable pulleys will give the necessary reserve, whether the engines are of the Willans type, running at 300 or 400 revolutions per minute, or steam turbines with 10 times the speed. The calculation of sizes and weights is a mere matter of arithmetic, which need not be dealt with here; any pulley manufacturer's list will give the limits of speed for different materials with a proper factor of safety as regards the breaking strain.

When a belt or similar connection between engine and generator dynamo is employed, there seems no substantial reason why a heavy flywheel should not also be arranged on the dynamo axle; there is at any rate no doubt that in the generating plant of both the Liverpool Overhead Railway and the South Staffordshire Tramway, the massive grooved rope pulley, mounted on each dynamo spindle with a third bearing outside, must exercise a considerable regulating effect upon the variations in the load required from the engines.

With regard to all these plans of arranging flywheels as regulators, it must be remembered that the essence of their successful operation is the extremely short period of time during which they are called upon to act. It is only for 20, 30, or 40 seconds, or at the most a single minute, that the maximum load comes on, and probably long before the reserve of energy contained in the revolving flywheels has been used up, the automatic expansion gear on the steam-engine will have retarded the cut-off sufficiently to make up the engine power to the extra amount required.

A few remarks, in conclusion, may be made with reference to improving the load factors of tramway plants by careful attention to the energy *receivers* as well as the energy *generators*. So far, our only consideration of the subject has been from the station end: it is, however, to be noted that the chief causes of excessive variation in the load of a tramway generating plant are first and foremost the heavy calls at starting or running uphill; whilst in addition the state and arrangement of rails and permanent way generally will have some effect upon the total power required.

The first of these causes *may* (I do not say *will*) be largely removed if some satisfactory arrangement of variable gearing on the car is devised. On this point, it is much to be regretted that no extended practical results of a system like that of Beaumont's are as yet available. Until, however, we have at hand some reasonable experience of these devices, it is no use remarking how theoretically admirable they may be.

With regard to the second—and much less important—cause of load change, the details of any remedial measures are rather ouside the scope of this article; they involve so many considerations that separate treatment would alone do the matter fully justice. Perhaps, when their importance requires it, this may be done.

INSTITUTION OF ELECTRICAL ENGINEERS.

THE ELECTRICAL TRANSMISSION OF POWER FROM NIAGARA FALLS.

BY PROF. G. FORBES, F.R.SS. (L. AND E.), MEMBER.

(Concluded from page 491.)

It will be obvious from this design, considering that the speed of revolution is 250 per minute, that great care has to be devoted to the balancing of the revolving parts. Everything has to be calculated not only for a speed of 250 revolutions, but for double that amount, which is the maximum speed at which the turbines could possibly run—at which speed they might run through a breakdown of the governor, although this is an accident almost impossible to occur. Each of the revolving parts will of course be balanced individually, and I have suggested a plan for the final balancing which seems likely to be effective. A temporary bushing would be put in the bearings of india-rubber lined by a thin metal tube. The dynamo would then be rotated slowly and the balance adjusted in the usual way. The speed of revolution would be gradually increased—a new adjustment being made at each speed—until a speed of 500 revolutions a minute is attained, and when an adjustment has been made at this speed it is pretty sure that the balance at 250 revolutions per minute will be very perfect, and the mechanical friction reduced to a minimum. As stated before, the oiling arrangements have been introduced, not only to ensure higher insulation and to preserve the insulating material, but also to lower the temperature as much as is possible, because every step we take in the reduction of temperature is an advance. These oiling arrangements may perhaps be adopted in the future, but at present we are not making use of them in the machines which are in process of construction. When we have had experience with these we may in future adopt the oiling arrangements; and as there is likely to be a great development in the direction of electric transmission of power in connection with the utilisation of water power in many parts of the world, it has seemed well to me to put before you these details, so that they may be considered in other cases that may arise. At a meeting of the Board of Directors in New York lately it was resolved, on the recommendation of the consulting engineers of the company, that the contract for two or three alternators, each of 5,000 h.p., should be assigned to the Westinghouse Electric and Manufacturing Company, of Pittsburgh. I would wish to state how much we owe to Mr. Westinghouse, and to his chief engineer, Mr. Schmid, for the zeal with which they have taken this matter up, and their desire to meet our views and to secure for us machines of which they felt they could guarantee the satisfactory performance.

Before leaving the subject of the dynamo, I would wish to point out that it has been designed for special circumstances in connection with the Cataract Construction Company's work. If a dynamo of the same type were being constructed for another place it is certain that modifications would have to be introduced. I particularly draw attention to the fact that some trouble in getting out a good mechanical design arose from the necessity which existed of being able to provide a clear space of about 5ft. diameter in the middle of the machine without taking the whole machine to pieces, the object of this being to enable us to lift up portions of the turbine shaft which it might be required to put into repair. In any case where the long shaft existing in our case is not required, the design of the dynamo is much simplified, and would more nearly approximate to the first design of which a drawing is shown, but arranged for 33 periods a second. If the present paper were intended to relate solely to the subject of the utilisation of power at Niagara Falls, I would be content with describing what has actually been done, but I foresee that there is going to be a great development in utilisation of water power, and its electrical transmission. I am therefore inclined to say a few words on some other details which we have been carefully considering, but about which no definite decision has been arrived at. Before doing this, I would direct your attention to the drawing representing a plan of our power-house, in which you will perceive the inlet passages, A, from the great canal, B, which draws its supply of water from the upper river. From these inlet passages, the iron pipes, or flumes, C, pass vertically downwards to the bottom of the great wheel pit, which is a slot cut in the ground to a depth of nearly 200ft., at present large enough to contain four turbines in line, but which can be extended to a much greater length, the whole capacity of our tunnel being 100,000 h.p. The drawing shows circles, D, in the plan, which indicate the position of the turbine and dynamo above it; and the position of a hatchway, F, by which materials can be raised or lowered. It will be noticed that between the inlet channels and the wheel-pit the flumes are bent downwards, and thus leave a V shaped space, G, which I have appropriated to make a subway, running along the whole length of the power house, to carry the high pressure conductors. It will of course be understood that the slot forming the wheel-pit is arched over at the top to form the floor of the power house, upon which the dynamos rest. It will be noticed that at the north end of the power house there is a large square chamber, H, in which I propose that all the measuring instruments and other apparatus under the control of the chief electrician shall be assembled. Underneath this chamber there is a cellar, in direct communication, first, with the subway which I have described as existing in the power house, and second, with the subway which leads outwards from the power house at present as far as the Pittsburgh Reduction Company's works, and may possibly eventually lead to Buffalo. In this cellar all the high pressure wires, the transformers, the artificial load, and other high pressure machinery, will be placed. It will be noticed that other spaces are left in the floor forming trenches along which the conductors can be carried. With these arrangements there can be no possibility of danger to any person in the power house; and if any wires are to be found laid along the walls of the power house or elsewhere, I wish it to be a maxim that we shall be able to place upon these wires a card marked "No danger," so that there will be no possibility of danger from any person touching anything in the power house.

With regard to the exciting current, the best plan available at this moment is to use one of the machines which are generally

known as the Schuckert machines for converting the alternating into a continuous current, transformers being inserted in order to lower the pressure. In order that the exciting current may increase with the load, it would be well to make these transformers of special construction, each having two primaries and one secondary. One of the primary coils would be in series with the main circuit, and the other in shunt. I would furthermore make these transformers sufficiently large to deal with all the dynamos which are in the central station, and I would subdivide the secondary coil into sections, to enable us to cut out a section of the transformer when we cut out one of the dynamos. When we wish to cut out a dynamo, a switch would be worked which would at the same time short circuit the field coils of that dynamo and also cut out one section of the secondary of the transformer which is supplying the exciting current to all the dynamos. This plan allows the fields of all the alternators to be put in series—a desirable arrangement for parallel working. A resistance may, of course, be put in circuit with the fields of the alternators for regulation.

I presume it will be taken for granted that in any large work of this sort the primary circuit should never be broken when in action. For my part, I hold that this should be the case even in smaller stations.

An important feature for putting the dynamos in parallel, and for removing a dynamo, is an artificial load. It is desirable that this artificial load should consist partly of a resistance and partly of self induction. It is only by this means that the dynamo which is going to be put in circuit can be brought to exactly the same condition as those which are working, both as regards volts and amperes. It may be well to describe the operations which take place when a dynamo is switched in parallel with the others. First, connection is made between the armature and the artificial load; then the exciting switch is turned so that an extra section of the transformer is put into play, and the short circuit on the field coils of the dynamo is broken. The dynamo being excited, the turbine is then started, or this may be done at first. The artificial load is then adjusted until the dynamo is giving the same volts and amperes as the others. A synchroniser is then placed between the artificial load and the external circuit, and so soon as synchronism is attained a switch is closed which connects the artificial load with the external circuit. Resistance is then put into the artificial load until there is very little current going through it, when it is switched out, and the dynamos are all working in parallel. To cut out a dynamo from the circuit the operations are performed in the opposite order. The artificial load with high resistance is put in connection with the external circuit; this resistance is gradually diminished until it indicates the amount of work that is being performed by one dynamo: the connection between the artificial load and the main circuit is then broken, leaving the dynamo (which is being switched out) feeding the artificial load. The resistance of the latter may then be increased, and the exciting switch actuated so as to short circuit the fields of the dynamo, and to remove one section from the secondary of the exciting transformer. The supply of water to the turbine may then be shut off.

If machinery is worked, even at 20,000 volts, in the manner I have described, there is no possibility of injury from any great rise of electrical pressure, unless the external circuit be by any means accidentally broken. To provide against this sort of trouble I would have wires coming from the external circuit where it enters the power house connected through a large resistance, or through the primary of a transformer the secondary of which contains a resistance. In circuit with it I would have a break consisting of two carbon points at a distance of about half an inch apart if we were dealing with 20,000 volts, so that an arc could not be formed unless the pressure rose above the normal value. Under these circumstances, so soon as any resonant effect due to the breaking of the circuit or due to any other cause raises the electric pressure above the normal, an arc is established across the carbon points, and so a load is put on which removes the cause of the extra high pressure. This is the only automatic means which I have been hitherto able to think of which is sufficiently rapid in its action to overcome any possibility of injury to the dynamo or transformers.

I have attempted in the course of this paper to give you some idea of the work which has been actually done or decided upon at Niagara Falls, and also to show you the views to which I have been led by any special experiences which I may have had as to the general ideas which ought to guide us in the construction of plant in the future for transmitting power to a distance electrically.

In describing the different plans which are available, I have avoided mentioning the names of those numerous electrical engineers and manufacturers who, by their inventions, researches, or applications, have advanced the art; or discussing their claims to priority but I cannot conclude this paper without mentioning the names of some of those who, in one way or another, have made great steps in the applications of alternating currents to power purposes. I would particularly mention the names of Messrs. Ganz and Co., Mr. Schuckert, the Allgemeine Elektricitats Gesellschaft, of Berlin, the Oerlikon Fabrik, and Messrs. Brown, Boveri, and Co; also Mr. Eickemeyer, Mr. Ferranti, Prof. Ferraris, Prof. Fleming, Dr J. Hopkinson, Messrs. Hutin and Leblanc, Mr. Rankin Kennedy, Prof. Mengarini, Mr. Mordey, Mr. Tesla, Prof. Elihu Thomson, and Mr. Henry Wilde. I feel that all of us owe a great deal to their work.

In conclusion, I wish to draw attention to the figures which show the relative merits of high and low frequency with polyphase motors.

Everything is identical in the two figures, except that—the frequency of one (a) being double of the other (b) a has 16 poles, b has 8. The armature is identical in both, and revolves at the same speed and does the same work; and the field revolves at the same rate in both, and the induction and current density are the same. The differences are that a has more copper and less iron than b. The comparison of efficiency depends on the depth of both. As an example, assume that a has 50 per cent. more copper in the fields than b, the ampere-turns per pole being necessarily the same in both, and that b has 50 per cent. more iron than a, and that the hysteresis loss in b (= H_b) is equal to the resistance loss in its copper coils (= C_b). The values for a are

$$H_a = 2 \times \frac{2}{3} \times H_b ;$$

$$C_a = \frac{3}{2} C_b ;$$

$$H_a + C_a = \left(\frac{4}{3} + \frac{3}{2}\right) \frac{H_b + C_b}{2} = 1{\cdot}42 \times (H_b + C_b).$$

Thus the total losses in the field of higher frequency (neglecting eddy currents) are 42 per cent. more than in the field of lower frequency.

DISCUSSION.

(Continued from page 491.)

Mr. G. Kapp, continuing, said that the result was that if they compared different systems of transmission, they must have a basis of comparison. The basis which he took was the practical one of working, or, rather, putting it as a primary condition that the systems compared should have the same safety as regards insulation. The system that Prof. Forbes recommended as economical was the worst; with continuous current 100 tons of copper were required, with alternating single or two phase 200 tons, and three-phase 250 tons, the two-phase with three wires requiring 290 tons, and being entirely out of the question. He knew of no gain of 3 per cent. by reducing the frequency. With regard to synchronising motors, even if two rings were put upon the commutator how was the motor to be started? A Tesla motor must be put down to do it. If they had to do that, they might just as well use a Tesla motor. There were single and multiphase motors on the market, but he thought the electrical journals had served them badly by not fully dealing with the three-phase system. He had tested a single phase motor, and the following was the result: The machine gave on the brake 882 watts, and it ran at about 1,800 revolutions. The frequency varied between 60 to 67; the commercial efficiency was 60 per cent., and the power factor 74 per cent. At starting, the current to produce the torque equal to its full output was 2¼ times the normal working current. The weight of the machine was under 1cwt per horse-power. With regard to Prof. Forbes's type of alternator, he thought it was about the best machine that could be made for that particular job. The speaker had worked out a machine adopted by the author, and the following was the result:

5,000 H.P. ALTERNATOR—250 REVOLUTIONS.

Frequency	16·6	33·3
Number of poles	8	16
Volts on open circuit	22,200	21,500
Losses per cent	2·145	1·660
Armature plates, pounds	32 000	20,500
Magnet ,, ,,	12 000	10,000
Yoke ring ,,	38,500	18,200
Field copper ,,	7,200	7,000
Armature copper ,,	5,500	2,500
Total	95,200	59,100
Pounds per electrical horse power	19	11·8

The machine worked out to a weight of 19lb. per electrical horse-power with a frequency of 16, and 11·8lb. with double the frequency.

Prof. S. Thompson congratulated the author on the step forward in our appreciation of the problem of the utilisation of power such as that of the Falls of Niagara. He could not quite understand the apologetic tone adopted by Prof. Forbes throughout the paper as if he should not have given reasons for not having adopted the continuous current, and yet he had been coming to it by adopting the low frequency. With regard to the difficulties of working stations from sudden rushes of current when a field was thrown in or out, all station work tended to simplify this, and although switches were provided, yet one knew that in practice a large current was not broken. All station engineers fell in the way of operating that enabled them to slow down their engines or something else to prevent a large rush of current when the switch was closed. He did not think the curve of efficiency of alternating current motors was to be accepted without hesitation. He was glad that the works at Niagara had not been called a central station, which was misleading but a power station.

Mr. J. Swinburne observed that the first point that struck him was not the purely electrical question, but the commercial one—namely, what was the power going to cost, what would it be sold at, who were the persons that wanted it, and what were they going to do with it? The cost of the power was not given in the paper, and the question was very curious. In most industries the power used was quite a small proportion of the cost of running a factory, in others it was a large proportion. In tearing up wood pulp power was a serious matter, but not in flour milling. Some time ago, in conjunction with Mr. Thwaite, he worked out a

scheme for transmitting power from the Midlands to London. He found that the interest and the capital was so enormous as compared with the cost of coal as hardly a fact to be at all considered. As to those who were going to use the power, the problem was entirely different where it was wanted to supply a lot of small users requiring $\frac{1}{10}$ h.p. to ventilate their eating houses, and drive away flies or run printing machinery with power of from 1 h.p., 2 h.p., or 5 h.p., or wherever they wanted to operate aluminium works requiring hundreds of thousands of horse power. There was no difficulty in making motors for large powers. The difficulty of starting did not come in with very small motors; the only difficulty was with those of medium size. Discussing the question of frequency, he said that it very much depended upon the class of consumers who were going to use the motors. With regard to the extra output from a double current, the matter was considered as early as in 1887 at Messrs. Crompton's, when an enquiry for a large power transmission in Australia was discussed. The alternating current was settled upon, and Mr. R. B. Rogers suggested at the time that the best way was to use a double current. In fairness to Mr. Tesla and others, he mentioned that he did not think that Mr. Rogers realised that this double current plant would be self starting. The extra output was a little illusory when large machines were dealt with. He protested against a large number of statements of a general character, such as "a high frequency is a good thing in a given case, all other things being equal." He would like to say much about dynamos in parallel, but it would take an evening or so to discuss the matter. The question was not entirely one of the dynamo, but everything else had to be taken into account. Some years ago he investigated the matter of a frequency of 25, and found that he was wrong.

Mr. S. F. Walker asked the cost of the half-mile of culvert. It appeared to him that towns here would come to that method, where a man could walk upright and examine the cables. The speed of the alternators, which were very heavy machines, appeared to be high.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE V.

(Continued from page 498.)

Heating Air before Use in Motors.—The amount of expansion which can be permitted in air motors, without inconvenience from the fall of temperature, is limited. Any difficulty thus arising is obviated if the air is heated immediately before it is used.

Quite apart, however, from the removal of a practical difficulty, the reheating of the air before use is of the greatest economical importance. The air when heated expands, and more work is obtained in the motor per pound of air used. Whether it is economical or the reverse to heat the air before use depends on this—whether the additional work obtained is more or less valuable than the coal expended. Experience shows that it is extremely advantageous economically to reheat the air. The heat supplied is used with great efficiency, and a larger fraction of it is converted into work than in ordinary heat-engines. Further, very small, easily managed, and simple reheating apparatus can be employed. A simple coil of pipes, with a small furnace capable of heating the air current to 300deg. F., may increase the work done per pound of air by 25 or 30 per cent. The heat, according to the experiments of Riedler and Gutermuth, is used five or six times as efficiently as heat supplied to a good steam engine.

Fig. 28 shows a simple form of reheating oven. The compressed air passes through a double spiral pipe, C. The furnace gases rise through the centre of the coil and descend on the outside in a cast-iron casing, with a spiral diaphragm or rib. The grate is at F. The air discharged from the motor, M, may be used to create a chimney draught. This has the advantage that the draught varies with the amount of work done. As air does not readily take up heat from metal surfaces, it is advantageous to introduce a small quantity of water into the spiral pipe of the reheater. The water is evaporated into steam, and in the motor the steam condenses, giving back the latent heat to the expanding air. The water may be supplied from a reservoir above the oven, to which the air pressure is admitted, so that the water descends into the heater by gravity. The reservoir can be refilled by shutting off the air pressure. Steam thus used is extremely efficient in increasing the work done by the air, and probably the moisture in the cylinder helps to prevent wear and leakage.

In some simple reheaters, tested by Prof. Gutermuth, in Paris, the air was heated from temperatures of 45deg. to 122deg. up to temperatures of 224deg. to 303deg. From 8,035 to 10,070 thermal units were given to the air per pound of coal used. About 5,200 thermal units were transmitted to the air per hour per square foot of heating surface.

Combination of a Gas Motor and Air-Engine.—In a scheme for distributing power chiefly by compressed air, for the town of Dresden, Dr. Proell proposed to work an electric lighting station partly by air motors and partly by gas engines. The ordinary reheating apparatus for air motors is not very convenient in this case, in consequence of the great variation in the demand for power. Hence Dr. Proell adopted the plan of combining gas-engines with air motors. The gas-engine is itself a very efficient and convenient motor for an electric lighting station, because it can be put in action or stopped, according to the variation in the demand for power, and there is no waste like that due to keeping boilers in steam ready for use. But in gas engines a very large fraction of the heat developed is necessarily wasted in the water-jacket. Dr. Proell proposed to abolish the water jacket, and to take the compressed air through the gas engine jackets, to reheat it on its way to the air motors. In addition, the hot gases rejected from the gas engine were to be used in the jacket of the air motors. Undoubtedly by the combination of the gas engine and the air motor, a quite remarkable thermal efficiency could be obtained.

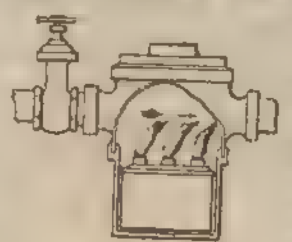

FIG. 29.

It may be questioned whether it would not be better to take the exhaust of the gas engine directly into the air current. Then the gas engine would work with a heavy back pressure, but the work so lost would be recovered in the air motor. In a paper on compressed air,* the author suggested reheating by the burning of gas in the air current, so that the whole of the heat would be utilised without chimney losses. Some attempts have since been made in this direction in America. Fig. 29 shows a small petroleum burner used in the air-main supplying compressed air to rock drilling machinery.

Meters for Measuring Air Supplied to Consumers.—Various types of meters have been used in compressed-air systems. Very accurate displacement or positive meters can be constructed, but they are costly; hence inferential meters, which are virtually air turbines driven by the air current, are more commonly used. Fig. 30 shows an arrangement designed by Mr. Abrahams, of the Birmingham Compressed Air Company, which is stated to have worked with an accuracy within 1 per cent. With a simple fan or turbine, driven by the air current, the velocity of the meter is not proportional to that of the air current in consequence of the friction of the meter. If set to be right, at a mean velocity, it over-registers with a fast current, and under-registers with a slow current. Mr. Abrahams added a kind of pendulum governor, the balls being replaced by hemispherical cups. The governor creates a resistance increasing with the radius of the circle in which the cups revolve, and therefore with the speed of the meter. This extra resistance may be made to balance the tendency to over-register.

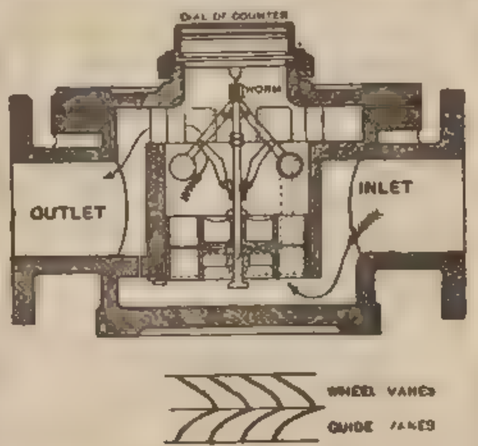

FIG. 30.

Distribution of Power by Compressed Air at the Works of the Societe Cockerill at Seraing.—The great works at Seraing may be considered the birthplace of modern compressed air machinery. The compressed air plant for the Mont Cenis Tunnel works was made at the Cockerill Works, having been designed and constructed under the direction of Mr. J. Kraft, who is now at the head of the engineering staff of the works. In conjunction with M. Sommeiller, Mr. Kraft carried out extensive experiments on the efficiency of air compressing machines in order to obtain the necessary data as a guide in attacking what was then a new problem. Compressed air in mines was first used and is still extensively used at the Marihaye Collieries at Seraing. Further, since 1854 compressed air has been used in the engine works of the Societe Cockerill for working cranes.† With regard to this last application, Mr. Kraft states that "it might be expected that the losses of power incurred in the production and utilisation of compressed air would cause it to be rejected as a motive power. But in many cases it is not so—for instance, for a series of cranes, machines working only at intervals, where steam is used, enormous losses are caused by condensation in the pipes; and expansion and condensation can hardly be used in the engines; whereas, on the other hand, compressed air can be produced by high class engines consuming very little coal. In this way, the loss incurred by employing air may be compensated for. For a set of cranes like those at the Cockerill Works, or at Portsmouth Dockyard, steam cannot compete with air. The principal rival of compressed air is water, and there are many cases where water is to be preferred. For cranes placed in the open air in cold countries, the great impediment to the use of water is frost. For the installation of a number of cranes in the open air, along a quay

* Howard Lectures delivered before the Society of Arts.

* "Transmission of Power by Compressed Air," *Proceedings* Institution Civil Engineers, vol. xciii.

† "Notes on Compressed Air and Machinery for Utilising it." By John Kraft. *Proceedings* Institution of Civil Engineers, vol. lxxxix.

wall, Mr. Kraft thinks that air is preferable, as in the case of Portsmouth Dockyard." The compressed air machinery erected in the engine works at Seraing in 1885—and still in use—consisted of the following machines: (A) Air compressing engine, with two cylinders. Diameter of steam cylinders and air-cylinders, 13·78in.; stroke, 29·53in.; revolutions per minute, 26. (B) Air reservoirs (two). Length, 36ft.; diameter, 6⅝ft.; maximum pressure, five atmospheres; diameter of pipes, 2in. (C) Forty ton travelling crane, with two double cylinder air motors. Diameter of cylinders, 4·53in.; stroke, 7·09in. The air is supplied to the traveller by a flexible pipe, which coils on to or off a drum, as the traveller approaches to or recedes from one end of the building. The crane has worked very satisfactorily, and was at work this year (1893). (D) Three four ton swivel cranes. (E) Air motor working hydraulic pumps for wheel press. (F) Twelve 12-ton swivel cranes. (G) Two 15 ton swivel cranes.

The compressing engine stops automatically when the pressure reaches 73lb. per square inch, and begins working again when the pressure falls. The air cranes differ in no respect from steam cranes, so far as their engines are concerned; and all can be worked with a pressure of 45lb. per square inch. Also an overhead traveller, with a reservoir of air at 90lb. has been erected in the foundry. The air is supplied to the engine through a reducing valve at 40lb. per square inch.

Compressed Air in Mines.—One of the largest mining plants worked by compressed air is that at the Chapin Mine, Michigan.* About three miles from Iron Mountain at Quinesec Falls, on a head of 52ft., 1,700 h.p. is obtained by four turbines. Each of these drives two Rand compressors. About 2¼ million cubic feet of air are supplied per day at 60lb. per square inch gauge pressure. From the compressor plant, a 24in. wrought iron main, ⅜in. thick, extends for three miles, an expansion joint being used at every 480ft. The air main is connected to the machinery, and to 105 power drills at the Chapin Mine, and also to some neighbouring mines. Most of the machinery is arranged so that by closing one valve and opening another a change can be effected from working by air to working by steam.

System of Transmitting Motive Power by Vacuum.—An interesting plant for distributing motive power by vacuum was established in the Rue Beaubourg in Paris by MM. Petit and Boudenoot. The general object in view was the distribution of power to small industries. From 1874 M. Petit had the idea of transmitting power by vacuum. In 1882 an association was formed and machinery erected. Conduits were laid communicating with the houses of consumers, who paid a rental based on the number of rotations of their machines, ascertained by a counter. The users of power were interested in the success of the scheme by participation in the profits. The working hours are from 7 a.m. till noon, and from 1 p.m. till 8 p.m.

* See the "Iron and Steel Institute in America," p. 378.

A steam-engine and exhausting pump of 70 h.p. to 80 h.p. was first erected, the mains extending 300 to 400 yards. Now there are three steam-engines, developing altogether 300 h.p., and the mains extend 850 yards. There are about 150 small motors on the mains. Part of the power is rented to an electrical company. This power is supplied by a fourth engine of 100 h.p. M. Boudenoot gives the preference to a vacuum system, because the cost of machinery is less than for a compressed-air system. The mains are always dry, and do not require draining boxes. Lastly, the efficiency of a vacuum system is greater. M. Boudenoot takes the efficiency of the exhausting pump at 0·93, the mechanical efficiency of the vacuum motor at 0·60, and the efficiency of the expanding air in the motor at 0·85. The resultant efficiency is then

$$0{\cdot}93 \times 0{\cdot}60 \times 0{\cdot}85 \times 0{\cdot}95 = 0{\cdot}45.$$

This, for small motors, is a good result. The exhausting cylinders make 20 to 50 revolutions per minute, and maintain a vacuum of 0·67 to 0·80 atmosphere. These cylinders have spray injection. The motors are constructed to supply 360, 540 and 900 foot pounds per second. There is a vacuum reservoir 50in. in diameter and 140in. in height attached to each motor. The vacuum mains are 10in., 8in., 6in., and 4in. in diameter. The house service pipes are of lead.

(*To be continued.*)

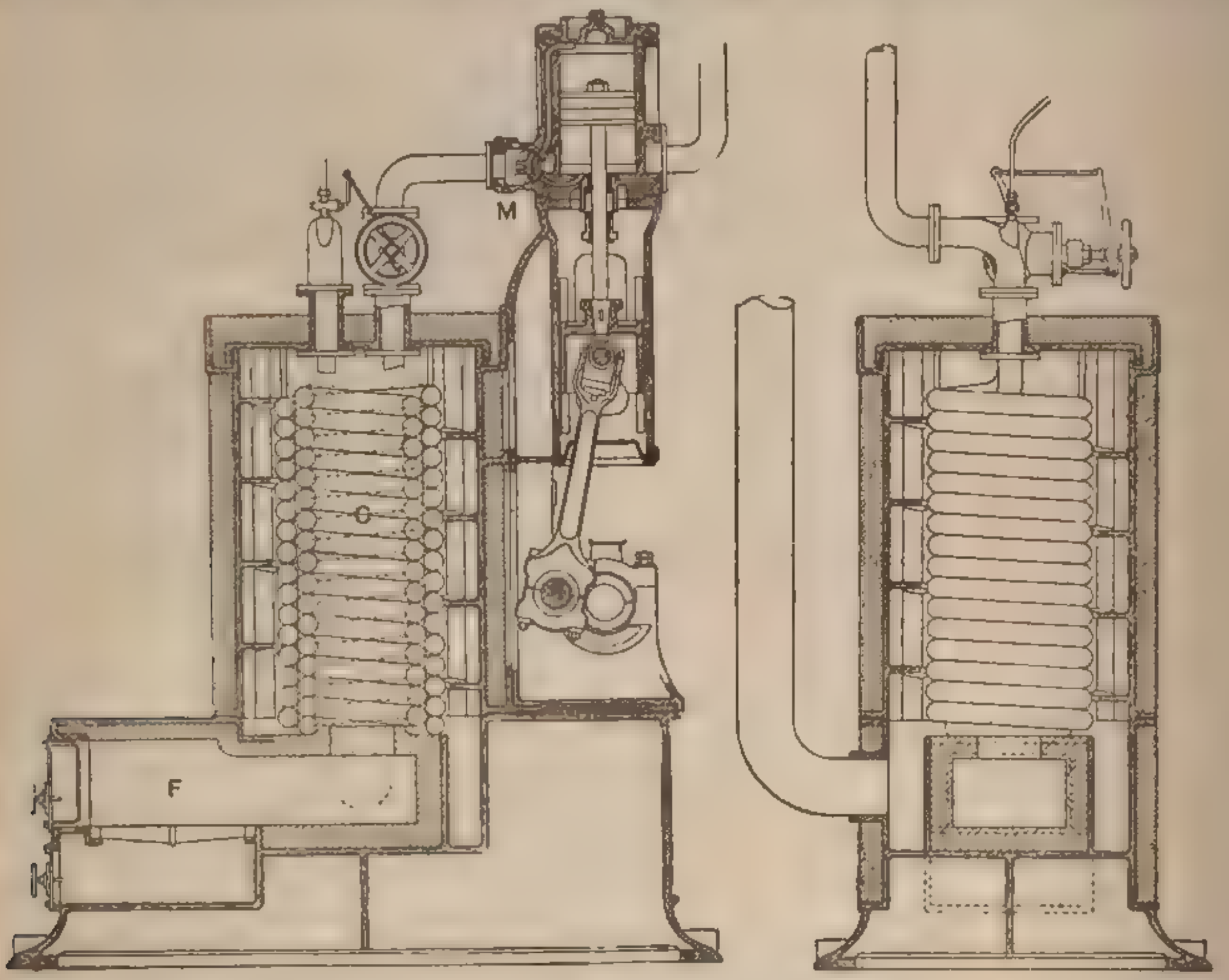

Fig. 28

PHYSICAL SOCIETY, Nov. 24, 1893.

Prof. A. W. Rücker, M.A., F.R.S., president, in the chair.

Colonel Maitland, C.B., was elected a member of the society.

Prof. S. P. Thompson then occupied the chair whilst the **President** read a paper "**On the Magnetic Shielding of Concentric Spherical Shells**." In this mathematical investigation the author considers cases in which the equipotential surfaces are surfaces of revolution about a line through the centre of the shells, and the permeability, μ, of each shell is constant. Taking the common centre as origin, the potential within any shell is expanded in terms of zonal spherical harmonics, and the ratio of the shielded to the unshield field determined. The following important result is arrived at—viz., if the permeabilities of the enclosed and external space be the same, then the ratios of the shielded to the unshielded fields are the same for each harmonic term, whether the part shielded be external or internal. It is also shown that the shielding effect on external space when a small magnet is placed at the centre of the shell is the same as the shielding effect on the enclosed space when the shells are placed in an uniform magnetic field. The case of a single shell with a small magnet at the centre

is next considered where the permeabilities of the internal and external spaces are taken as unity. Here the shielding depends on the ratio of the outer to the inner radius a_1/a_0. When the thickness of the shell is $\frac{1}{10}$ of a, the ratio of shielded to unshielded field, ψ_i/ψ_0, is $\frac{1}{12}$ when $\mu=500$, and $\frac{1}{24}$ when $\mu=1{,}000$. For $\mu=1{,}000$, increasing the thickness from $a_1\frac{1}{10}$ to $a\frac{1}{4}$ changes the shielding from $\frac{1}{24}$ to $\frac{1}{102}$, thus showing that after the shell is moderately thick further increasing the thickness is not very effective. When the small magnet is displaced from the centre of the shell with its axis along a radius, then the shielding effect of the shell is greater on the side towards which the magnet is moved, and less on the opposite side. Thickening a single shell being inefficient, the effect of using two or three shells separated by air gaps is investigated. Here, as in the case of a single shell, the shielding is improved by adding permeable material either within the inner or without the outer shell. If the inner and outer diameters are given, then, when the difference in these diameters is small, one continuous shell gives the best result. For a larger difference, two shells operated by an air gap are much more efficient than a single one, and filling up the air gap would appreciably diminish the screening effect. When the permeability of the substance is high, the best shielding is obtained when the radii of the bounding surfaces of the shells are in geometrical progression. The great value of lamination is shown in the following table, where the volume of the permeable material is expressed in terms of that of the enclosed space, and the shielding in each case being the best:

	Volume of material used.	External field.
Single shell	1·0	0·018
Two shells	5·0	0·0008
Three shells	4·8	0·00016
Single shell	7·0	0·0102

The conditions for the best arrangement in each of the following cases are fully worked out in the paper, viz., two shells where the largest and smallest radii and the volume of the material used are given, two contiguous shells of different permeabilities, and three shells of different permeabilities. The main results of the investigation are that with thin shells lamination is useless, whilst with thick shells it is essential, if the best effect is desired. Experiments made on actual shells had fully confirmed the theoretical conclusions. **Prof Minchin** said the mathematical results were very simply expressed. Although the work was apparently restricted to zonal spherical harmonics, some of the important formulæ apply equally to general spherical harmonics. Referring to the difficulty of shielding by single thick shells, he pointed out that the equation giving the relation between the shielded and unshielded fields with different thicknesses of shell, represented a hyperbola with its asymptotes parallel to the axis; hence the shielding tended to a definite limit as the thickness increased indefinitely. **Mr. Evershed** said he had been engaged for the last two years on the subject of magnetic shielding, with a view to screening measuring instruments from external fields. In such cases it was not possible to use closed shells, and this introduced trouble. The best results he had yet obtained was to reduce the disturbance to about one-fifth. Another difficulty was introduced by the fact of the shield being magnetised by the current passing through the coil, and owing to hysteresis the permeability was different according as the magnetisation increased or decreased. By using an outer iron shell a great improvement had been effected. To obtain the best results it was important to have no joints in the shields. A coil frame with two shields of bent iron was exhibited. **Mr. J. Swinburne** remarked that the subject divided itself into two—shielding of instruments and shielding sources. If a dynamo itself be shielded, this did not prevent the currents in the leads producing magnetic disturbances. This was very important in ships. By using an alternator with revolving fields, all disturbances could be avoided. **Dr. C. V. Burton** enquired whether by considering the hydrodynamical analogue of a porous material the case of perforated shells could be elucidated. **Mr. A. P. Trotter** wished to know if the homogeneity of the shield was of much consequence. At Oxford it had been found that a screen of 4in. of scrap iron was better than boiler plate. **Mr. Blakesley** asked if the effect of moving a magnet sideways in a sphere had been observed. He thought the mathematics developed in the paper would be useful in working out the magnetic theory of the earth. **Prof. S. P. Thompson** thought that taking the permeability as constant would not be quite correct, for μ was a function of the magnetisation. Hence, in the cases considered, the outer shell would be the more permeable. In his reply, the **President** said scrap iron in contact was not like clear space, for there were comparatively free paths for the induction at the points of contact. As regards the shielding of the dynamo at Greenwich, Mr. Christie had written to say that the credit was due to the makers of the machine and shields, Messrs. Johnson and Phillips.

Prof G. M. Minchin, M A, read a paper on "**The Action of Electromagnetic Radiation on Films Containing Metallic Powders**." After noticing the resemblance of the phenomena exhibited by tubes containing metallic filings, shown by Mr. Croft on October 27, to those of photo-electric impulsion cells, he repeated some of the experiments with filings, and found the same effects when the filings were of ordinary fineness. He also noticed that the experiments did not succeed either when the filings were coarse or very fine. Coarse ones always conducted, whilst very fine filings or powder acting as insulation, except when strongly compressed. To establish a closer connection with the impulsion cells, he tried films of gelatine and collodion containing metallic powders. Directions for preparing the films are given in the paper. On inserting such a film in circuit with a battery, key, and galvanometer, it acts as an insulator. To render a small portion conducting, the electrodes on the surface of the film are brought very close together, and one of the wires touched with an electrified body. (An electric gaslighter was often used.) This caused a current to pass. The electrodes may then be separated a little further, and the process repeated until any desired portion is rendered conducting. The peculiarity of such a film is that, if the circuit be broken at the film, the film becomes an insulator, whereas breaking the circuit at any other point leaves the film conducting. The action of the sparks or charges on the conductivity of the films is attributed to the influence of electric surgings produced in the wires by the electric discharges. The **President** read a written communication from **Prof. O. J. Lodge**, in which the writer suggested that the phenomena of the films, and also of Lord Rayleigh's water jet experiment (in which water drops are caused to coalesce by the presence of an electrified body) were due to the range of molecular attraction being increased by electric polarisation. **Mr. Blakesley** said he had tried Mr. Croft's experiments, and found that conductivity could be established in a tube of filings whilst the circuit was unclosed. Breaking the circuit of a transformer or electromagnet would produce conductivity, hence he concluded that electric surgings were not essential. Another curious experiment was to put the discharging knobs of an electric machine on a photographic plate at a distance of a few inches. On turning the machine, a small spark travels slowly along the plate from the negative to the positive knob. On reversing the polarity of the machine, the spark travels back along the same path, but if the polarity remains unchanged a second spark usually travels along a different path. **Prof. C. V. Boys** asked Prof. Minchin whether the films themselves or the contacts between the electrode and film is made conducting by the sparks? **Prof. S. P. Thompson** wished to know if ordinary photographic dry plates would serve the purpose. **Mr. Evershed** enquired whether the metal used as electrode made any difference. **Prof. Minchin**, in his reply, maintained that the phenomena were due to electric impulses. He had not tried photographic plates, and had always used platinum for his electrodes.

LEGAL INTELLIGENCE.

HOERTER AND ANOTHER v. HANOVER CAOUTCHOUC AND TELEGRAPH WORKS.

Judgment in this case, which was referred to in our issue of the 3rd ult., was delivered on Monday in the Court of Appeal, by the Master of the Rolls, Lord Justice Lopes, and Lord Justice Kay.

The case was an appeal from the Divisional Court refusing to set aside the writ of summons and service of the notice thereof on the defendants. The plaintiffs, who carried on business in London as C. F. Mumm, brought this action for commission on the sale of goods, as agents for the defendants, who were a foreign company carrying on business at Linden, near Hanover, and for an account. By a contract in writing made at Linden, in the German language, on June 21, 1890, as modified by another contract of December 4, 1891, the defendants appointed the plaintiffs, who were described as trading as C. F. Mumm, of London, their sole agents for the sale of their goods in the United Kingdom, Canada, and the United States of America until October 1, 1892, the plaintiffs to receive a commission of 5 per cent. "upon all net amounts of invoices received after deducting freight, duty, and packing," on all sales by them of the defendants' goods. The commission was to be accounted for quarterly, and the collection of the amounts of the invoices was to be made by the defendants alone. The contract further provided that in case of disputes the plaintiffs' firm was to submit to the laws and jurisdiction in force in Hanover. On February 27, 1893, the plaintiffs issued an ordinary writ against the defendants for service within the jurisdiction, and the writ was served upon one Gilbert, on the ground that he was an officer of the defendants, who had a place of business and carried on business within the jurisdiction. The defendants entered a conditional appearance, and on March 20 the Master on the application of the defendants, set aside the service of the writ on the ground that the defendants had no place of business here, and that Gilbert was a mere agent of the defendants. On May 2 the plaintiffs applied *ex parte* to Mr. Justice Mathew, at Chambers and he gave them leave to amend the writ by making it a writ for service out of the jurisdiction, and to serve notice thereof on the defendants out of the jurisdiction, under Order 11, r. 1 (e). Notice of the amended writ was accordingly served on the defendants abroad, and they entered a conditional appearance, and applied at Chambers to set aside the writ and all subsequent proceedings. Mr. Justice Wills set aside the notice of the writ and service thereof, upon the ground that the contract provided for the determination of disputes between the parties by the Courts of Hanover. The Divisional Court discharged this order, upon the ground that there was a breach of contract within the jurisdiction—namely, non-payment of the commission, and that the clause in the contract did not give the Courts of Hanover exclusive jurisdiction. The defendants appealed.

Mr. Danckwerts, for the defendants, contended that the affidavit upon which the plaintiffs obtained leave *ex parte* from Mr. Justice Mathew did not disclose the fact that they were suing upon a contract in writing which contained the clause providing for all disputes being settled by the Courts of Hanover. This was a very material fact to be stated, and in *ex parte* applications

***uberrima fides* was necessary** (Republic of Peru v. Dreyfus Bros.). The plaintiffs, in their affidavit, stated that the greater part of the goods were sold by them in England, but that they did not know the amount of the commission due until the accounts were taken. Therefore, this was an action for an account which would have to be taken in Germany, and no commission would be due under the contract until the account was taken in Germany. Accordingly, the plaintiffs were not suing for a breach of contract within the jurisdiction. Further, if there was a breach within the jurisdiction, the Court in its discretion would not in this case, where the account must be taken in Germany and where all the books and documents were, give leave to bring the action in this country. Again, the contract contained a clause providing that all disputes should be determined by the Courts of Hanover, and the action should be brought there. Further, Mr. Justice Mathew had no power to amend the writ by converting it into a writ for service out of the jurisdiction. The proper course was to have issued a concurrent writ for service out of the jurisdiction. Lastly the notice of the writ was bad in form by omitting to state the residence of the plaintiffs and the address of their solicitors.

Mr. Temple Franks, for the plaintiffs was not called upon.

The **Court** dismissed the appeal.

The **Master of the Rolls** said that first of all it was said that the writ was a bad writ. The writ was not good for the purpose of founding the service of a notice of writ abroad, but otherwise it was a good writ. The judge was asked to amend it. Order 70 gave very wide powers of amendment. The writ being insufficient for the purpose of service abroad, the judge had power to amend it, and he turned it into a writ upon which the plaintiffs could found service of a notice of it out of the jurisdiction. It was then said that there was a want of good faith when the *ex parte* application was made to the judge for leave to amend, upon the ground that the contract was not disclosed to the judge. But supposing the plaintiffs did not consider that the particular terms of the contract affected the question, where was the want of good faith? The judge might have said that the contract would be disclosed at the proper time when it was necessary to consider it. It was said that the contract contained a clause ousting the jurisdiction of the English Courts. The clause was in a German contract, and it must be construed according to German law. Was the judge at that stage of the proceedings to try the question whether that was its effect? Was he to examine the German law and hear evidence on the point? That was not the time to discuss the contract, and, therefore, even if the contract had been disclosed, it would have had no effect upon the question before the judge. The action was really by an English firm carrying on business in London to recover commission earned. That must be a liquidated sum. The plaintiffs were to be paid commission under the contract. The ordinary rule applied—namely, that the payment was to be made in England, where the creditors were. Therefore, the breach of contract sued upon—non payment of the commission—occurred in England. Therefore, the order of Mr Justice Mathew was right, and his discretion was rightly exercised. Mr. Justice Wills set aside the notice of the writ and the service thereof on the ground that the clause in the contract provided for the determination of all disputes by the Courts of Hanover. It was impossible to say that the clause was clear, because two judges in the Divisional Court differed from Mr. Justice Wills. That being so, the right course was to allow the service of the notice of the writ to stand, and to leave the question to be argued upon a subsequent application of the defendants, or to be disposed of at the trial. As to the alleged irregularities in the notice, if they had not already been amended, they could be amended now.

The **Lords Justices** delivered judgment to the same effect.

ELECTRIC AND GENERAL CONTRACT CORPORATION v. THE THOMSON-HOUSTON ELECTRIC COMPANY.

This action was heard last week, in the Queen's Bench Division, before Mr. Justice Wills and Mr. Justice Wright.

The case raised a question as to the right to retain a large sum paid by purchasers under a contract. It was an action brought to recover the sum of £1 000 paid to the defendant company by the plaintiff company under a contract for the purchase and delivery of certain electrical machinery and plant which were to be delivered to the plaintiffs at Liverpool from the defendants' factory in America. The terms of the contract contained in letters of May last were that the defendants were to deliver at certain prices (over £6 000) the electrical machinery specified "on ship's rail at Liverpool," the goods to be shipped from America by June 13 last. The plaintiffs were to pay for the apparatus and machinery £1,000 with the order confirming the contract, and 33 per cent on the invoiced amount on delivery of bill of lading, and the rest on starting of the apparatus. **The £1,000 was sent by the plaintiffs (the purchasers) with their** confirmation of the order, and certain apparatus and material were shipped and the bill of lading sent, but the sellers stopped the goods as the 33 per cent. were not sent on delivery of the bill of lading, and the purchasers now sued for the recovery of the £1,000, which the sellers resisted on the ground that it was a deposit or "earnest," and forfeited by the breach of the contract. The plaintiffs claimed to have summary judgment under **Order 14, but there was a counter-claim by the defendants,** and an order was made at Chambers giving the defendants unconditional leave to defend, against which the plaintiffs' company appealed.

Mr Shearman appeared on their behalf, and urged that the £1,000 was not a deposit but part payment, and so, the contract *being at an end*, it ought to be paid back.

Mr. Rawlinson, on the part of the defendants' company (the sellers), argued that the £1,000 was a deposit and so forfeited by breach of the contract, and therefore not recoverable: in support of which view he cited Stroud's "Judicial Dictionary," title "deposit or earnest," which so stated the law, citing authorities in favour of that view. [**Mr Justice Wills**, however, looking at the principal case cited, said that it did not support the proposition for which it was cited, where the money was "as part payment of deposit."] This was plainly as deposit or earnest; if not, what was it? The machinery was made entirely for the purchasers—the plaintiffs—at their order, and for their purpose, and will be useless in the hands of the sellers, who cross claim for damages for the very reason that it is impossible to estimate the amount of damages, which may be largely over £1,000. Surely, therefore, it is only reasonable that the sellers should retain it; and there is at least a good defence to the action, so that the plaintiffs cannot be entitled to summary judgment.

Mr. Shearman, in reply: The words used point to part payment, not deposit—"pay for the apparatus," etc.

The learned **Judges** conferred, and

Mr Justice Wills said he came to the conclusion that the order at Chambers was right. He did not think that Order 14, providing for summary judgment, applied to cases like this, raising what might turn out to be a difficult question of law. It was never intended to throw on the judge at Chambers such a burden. It was impossible that such questions could be satisfactorily dealt with at Chambers. This very case had been so argued as to occupy about two hours, and yet no time was wasted. Such questions were not meant to be dealt with summarily at Chambers. And on that ground alone he should uphold the order, allowing leave to defend. But, on the merits, he was not satisfied that the defendants—the sellers—were not entitled to retain the £1,000. When the plaintiffs—the purchasers—renewed the bill of lading they had not remitted the amount due under the contract, and, though they had properly returned the bill of lading, the sellers might contend that they were entitled to retain the money. **He certainly was not satisfied that the defendants** were not entitled to retain the money. At all events, it was far too disputable a question to be decided summarily. To decide such cases satisfactorily at Chambers was not possible, and it only tended to put the judge at Chambers in a false position. Further, in the present case, there was a substantial counter-claim. The order, therefore, made at Chambers was right.

Mr Justice Wright was of the same opinion. It was not shown that the defendants had not from the first conceived that they had a right to retain the £1,000, making, as they did, a claim for substantial damages.

The appeal was dismissed and the order upheld.

COMPANIES' MEETINGS.

INTERNATIONAL OKONITE COMPANY, LIMITED.

An extraordinary general meeting of this Company was held on Saturday at the City Terminus Hotel, Mr. Samuel Pope, Q.C., in the chair, to consider the confirmation of the resolutions passed at the meeting on the 27th September, for changing the name of the Company to the Okonite Company, Limited, and for making certain alterations in the articles of association.

The Chairman reminded them that at the last meeting they found themselves practically at the mercy of the American shareholders, who held a preponderance of the voting power. During the discussion on that occasion objections were raised to some of the propositions which had emanated from the other side, notably one for abolishing the power of the Company to purchase its shares—a change which would affect their standing on the Stock Exchange. The resolutions were passed, but the gentleman who held the proxies of the American shareholders said he would represent to his clients the views which had been expressed by the English shareholders. A letter had since been received from America agreeing to modify the resolutions to the extent of not interfering with the existing article as to the purchase of the shares by the Company, and therefore the resolutions would now be submitted for confirmation minus that point. He held that the best thing they could now do was to agree to the resolutions.

Mr. Williams then moved the confirmation of the resolutions, with the modification referred to.

Mr. Vaughan Stevens, in seconding the motion, stated that the capital of the Company was £340,000, and that Mr. Williams had lodged proxies representing £165,490 in favour of the motion.

The **Chairman** stated that the Board held no proxies. The effect of the proposal was to transfer the management to America.

Mr. Gladstone said that the Americans, who had sold the property to them at 10 times its value, now asked that it should be placed at their entire disposal.

The **Chairman**, in reply, stated that that was no doubt the individual opinion of many of them, but he felt powerless in face of the proxies which had been lodged by Mr. Williams. The position was that the American business was making profits, which the American shareholders objected to giving up to make good the losses on the English business. At the suggestion of the American directors the works at Manchester had been closed, but possibly they might be reopened at some future time. Speaking as an ordinary shareholder, he felt that the only chance he had of getting a dividend lay in the surplus profits of the American business.

After further discussion the resolutions were confirmed.

BUSINESS NOTES.

Chesterfield.—The Town Council are seeking for powers.

St. Helens.—A provisional order is being sought by the Corporation.

Chelmsford.—Messrs. Crompton and Co., Limited, are applying for powers.

Barrow-in-Furness.—The Town Council are seeking for a provisional order.

Plymouth.—The Corporation are applying for a provisional order. So is the gas company.

Hobart Electric Tramway Company.—For the mouth of October the earnings were £1,257.

Chipping Wycombe.—An application for electric lighting powers is being made by the Corporation.

Penrith.—The Local Board, as referred to on the 10th ult., are making application for a provisional order.

Western and Brazilian Telegraph Company.—The receipts for the week ended November 24 were £3,379.

Guildford.—The Urban Sanitary Authority intend to connect the isolation hospital with the police station by telephone.

Change of Address.—The address of the Roundhay Electric Tramway is now in Roseville road, Roundhay-road, Leeds.

Oystermouth.—We shall shortly be in a position to give further information concerning the proposed electric light scheme for this town.

Crystal Palace.—The Crystal Palace District Electric Supply Company, Limited, are to ask for permission for an extension of powers.

Balham, S.W.—Mr. Peton Dashwood proposes to light his shops in Balham High-road by electricity, and to erect arc lamps close to the kerb.

Yeadon.—The Local Board are applying for a provisional order to supply electricity within the district over which they exercise authority.

Willesden.—The Local Board have decided to apply to the Board of Trade for a provisional order to light the parish by electricity.

Govan.—Messrs. Hall, Brown, Buttery, and Co., of Govan, have received an order from Dundee for a high speed engine for electric lighting purposes.

St. Asaph.—Negotiations are proceeding between a Cardiff firm and some of the leading tradesmen with a view to lighting the town by electricity.

Croydon.—A local paper states that something will have to be done in the matter of electric lighting before long in Croydon, for the electric light will come into general use.

Kensington.—The Vestry have decided not to apply to the Board of Trade for a provisional order for powers to supply the parish of St. Mary Abbotts, Kensington, with electric light.

Harrogate.—Mr. Wilkinson, the consulting engineer to the Town Council, is to report on the feasibility of using a refuse destructor for electric lighting and pumping purposes.

Buxton.—The Local Board for the urban sanitary district are applying for a provisional order under which they may produce and supply electricity within the area under their jurisdiction.

Gorseinon Electric Light Company, Limited.—This Company has been registered with a capital of £10 000 in £1 shares, to carry on business as suppliers of electricity at Gorseinon, near Swansea.

Leeds.—An electrical clock was exhibited by Mr. J. H. Gash at the Leeds Naturalists' Club conversazione on Tuesday. It was manufactured for Mr. F. W. Branson by Messrs. Gash and Skilbeck, Leeds.

Working Partner Required.—A working partner having £1,500 is required by a West-end electric lighting and engineering firm. Applications to be sent by letter to X, 19, Blackhorse road, Walthamstow, E.

Paisley.—The Police Board have under consideration the provision of one or two small sub stations, such as are provided at Aberdeen, and two or three telephone-call signal boxes, similar to those in use in Glasgow.

Dublin.—Tenders are invited, as mentioned in our last issue, by the 14th inst. for the extension of the buildings and the supply and erection of additional plant at the central station, Fleet street, Dublin, for the Corporation of Dublin.

Brazilian Submarine Telegraph Company.—The directors have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended September 30 last, and payable on the 21st inst.

Ingleton.—At a meeting of ratepayers held at Ingleton on the 16th ult., to consider the question of the introduction of the electric light in the village, Mr. T. Preece (of Messrs. Andrews and Preece, Limited) addressed the meeting on the subject.

Huddersfield.—St. George's square is the first public thoroughfare in Huddersfield to be lighted by electricity. The current was turned on for the first time on Wednesday. Three powerful arc lamps on high pillars are found ample for the illumination of the large square.

Mevagissey.—The Mevagissey Vestry on Saturday received from the Lighting Committee estimates of the cost of lighting the town with oil, gas, and electricity. The committee reported in favour of the electric light, but recommended that the matter be deferred until parish councils had been formed. The report was adopted.

City and South London Railway Company.—The receipts for the week ending November 26 were £895, against £893 for the same period last year, or an increase of £2. The total receipts for the second half year of 1893 show an increase of £183 over those for the corresponding period of 1892.

J. Defries and Sons, Limited.—This Company has been registered with a capital of £100,000 in £100 shares. The object is to acquire the business of illuminating and decorating contractors, chandelier manufacturers, gas and electrical engineers, etc. hitherto carried on by J. Defries and Sons, at 147, Houndsditch, Gravel lane, London.

Coventry.—The Electric Light Committee of the Town Council have been instructed to draw up a list of instructions for their management. The following gives the names of the members of the committee: The Mayor; Aldermen Tomson, Hill, and Gulson; Councillors Fowler, Goate, Starley, West, Morton, Hughes, Thomas, James, Wormell, and Liggins.

Reading.—The temporary electric lighting of the Reading Town Hall, on the occasion of the visit of H.R.H. Princess Christian to open a bazaar there on the 23rd and 24th ult., was carried out by Messrs. T. C. Williams and Sons, electrical engineers, of Reading, by means of 17 high candle-power incandescent lamps, the current for which was supplied by the Reading Electric Supply Company.

Belfast.—The electric lighting of Queen's Quay, which was referred to in our last issue, was inaugurated on Friday in the presence of Mr. Giles, engineer to the Harbour Commissioners; Mr. George Combe, consulting electrical engineer for the contract; and Messrs. Siemens Bros.' representative. One circuit, comprising half the lamps of the entire number erected, was connected up to the machines. The other circuit is being thoroughly tested.

Cheltenham.—Major-General Babbage has addressed a letter to Colonel Hasted in connection with the latter's enquiry into the application of the Town Council for a loan for electric lighting. The Major submits that the time is not opportune for such an undertaking while urgent matters, such as preventing sewer inundations in basements of houses, procuring an adequate water supply, and other wants, exist far more urgent than electric lighting.

Greenock.—Tenders are invited for fitting a wooden steam yacht of 60 tons with electric light as follows: 20 4-c.p. incandescent lamps about cabins and saloons, two masthead lamps of 210 c.p. each, with wires; dynamo and engine of sufficient power to run all lamps at the same time. Tenders will also be considered for a second hand complete apparatus. Applications to be sent to Messrs. J. and H. M. Paterson, 32, Eldon street, Greenock.

Gas Traction Company, Limited.—This Company has been registered with a capital of £100,000 in £1 shares. The object is to acquire patents and inventions relating to the propulsion of vehicles by means of gas, and the construction and working of cars, and as suppliers of electricity, manufacturers of all kinds of machinery and apparatus connected with the generation, storage, compression, supply, application and distribution of gas and electricity.

Aberdare.—As stated in our last issue, an application is to be made to the Board of Trade for the issue of a provisional order to Messrs. J. C. Howell and Co., Limited, to enable them to supply the electric light in Aberdare within a radius of half a mile of St. Elvan's Church. The gas company have hitherto kept up the price to 4s. 3d. per 1,000ft., but now that the above-mentioned company are applying for parliamentary powers to employ electric light, the directors announce a reduction of 3d. per 1,000ft.

Wigan.—At a meeting of the Gas Committee last week a letter was read from the Corlett Electrical Engineering Company enclosing a list of persons who are willing to adopt the electric light if the Corporation will supply it at the same prices as other corporations. It was decided that the chairman, vice-chairman, Messrs. Jno. Johnson, Richards, Smith, and Rigby be appointed an electric lighting sub-committee, and that the above communication be referred to the sub-committee for report at the next meeting.

Kingston-on-Thames.—The Improvement, Property, and Sanitary Committee of the Town Council have agreed to consider the question of the means for the prevention of fire in the borough. Several questions were asked last week at a meeting of the Council by members as to the lighting of the public lamps. Councillor Baker stated that a few mornings since the lights were put out early, before it was light. Councillor Collings said that orders had been given for the lamps to be lit at sunset, and to be kept alight till seven in the morning.

Monmouth.—An enquiry has been held by Mr. Thos. Codrington, M.Inst.C.E., regarding a proposed loan of £18,000 for carrying out a complete scheme of drainage and electric lighting for the borough. Mr. C. W. Lailey, and Mr. R. A. Dawbarn, of the Brush Electrical Company, explained their plans. Some slight modifications were directed to be made in the scheme, and the Mayor promised that the drainage should be commenced at the earliest possible moment, the provisional order for electric lighting to be applied for in the meantime.

Jedburgh.—Preparations have been proceeding for the introduction of the electric light at Hartrigge House, the residence of Lord Stratheden and Campbell. A pond capable of holding 100,000 cubic feet of water has been made at the Tower Burn,

and from this pond the water is carried along a lade to a turbine, developing 20 h.p. Accumulators are also used. There are 140 lights for the house, 15 for the stables, and five for the laundry, making a total of 160. An electric motor is arranged in the stable yard for working small machinery.

Falmouth. Dr. Banks presented last week at a meeting of the Urban Sanitary Authority the report of the Lighting Committee, which recommended the payment of £8 to Messrs. Beale and Co. for their report upon the electric lighting scheme. In referring to some applications for more lamps he said the committee were averse to tinkering with the subject, but would like to have instructions for the preparation of a comprehensive scheme for the adequate lighting of the town by gas, electricity, or otherwise. The report was adopted, but no further steps were taken in the matter.

St. Pancras.—The St. Pancras Vestry invite tenders for excavating and constructing an underground water tank in connection with the electric lighting and refuse destructor station in King's-road, Camden Town, N.W. The drawings can be seen at the offices of Prof. H. Robinson, C.E., 13, Victoria-street, S.W., where a copy of the general conditions, specification, and schedules of quantities can be obtained on payment of five shillings, which will not be returned. Tenders to be sent in to Mr. Albert E. Pycraft, chief clerk, Electricity and Public Lighting Department, Vestry Hall, Pancras-road, N.W., endorsed "Tender for Water tank," before 12 noon on Friday, 8th December.

Belfast and Newtownards.—An adjourned meeting of committee has been held at Newtownards to consider improved railway communication between Belfast and Newtownards. Some correspondence, which had been elicited on a number of matters in connection with the scheme, was read, after which a sub-committee, who had been appointed for the purpose, presented a report on an interview they had had with Mr. Nance, manager Belfast Tramway Company, which stated that Mr. Nance recommended electricity as the best motive power. It being too late for parliamentary notices to be served for next session, the committee was continued to report on various matters in connection with the scheme.

Belfast.—The Corporation invite tenders for the following works in connection with their electric lighting station in Chapel-lane, Belfast: (1) Gas engines and dynamos, (2) switchboard and connections, (3) batteries, (4) laying of concrete culverts, (5) cast-iron work, (6) insulators, (7) insulated cable, (8) copper strip. Copies of any of the specifications can be obtained from Mr. S. Black, the town clerk, or from Prof. A. B. W. Kennedy, at his office, 19, Little Queen-street, Westminster, S.W. Firms wishing to obtain copies of any specifications must send with their application a deposit of one guinea for one specification or two guineas for any larger number; the deposit will be returned on receipt of *bona fide* tenders. Tenders are to be directed to the town clerk by the 15th inst.

Shepton Mallet.—The works of the Anglo-Bavarian Brewery Company are lighted with arc lamps on the Thomson-Houston system. The dynamo is situated near the fire brigade station, and is driven by a 60-h.p. engine. An interesting application of electricity has been successfully made as a motive power. The refrigerators used in the works involve a large consumption of water, and a spring has recently been acquired about half a mile from the works. Steam pumping would require an engine house at the spring, with the expense of keeping a man on the spot and of hauling coal across the fields to supply the furnace. By the use of electricity instead, the motive power can be supplied from the brewery itself, where the pumps can be started or stopped as required by merely turning a switch, and it is only necessary to visit the spring once or twice a day for the purpose of inspection.

Lighting at Halifax.—The Corporation, owing to the destruction by fire of the electric lighting works in Square-road, are pushing on their own electric lighting scheme with all speed. They have accepted tenders for the works required at the central establishment in Cripplegate. The engines are to be supplied by Messrs. Pollit and Wigzell, Sowerby Bridge; the boilers by Messrs. Yates and Thom, Blackburn; and the mains by Messrs. Siemens and Co. A project is about to be carried out to test the feasibility of generating steam for electric lighting and similar purposes with ashbin refuse as the only fuel. The power is obtained from Livet's expanding flue steam generators, capable of exerting 200 h.p. when town's refuse is burned. An electrical installation is being put down which will consist of a powerful turbo-electric generator, supplying a projector search-light of 25,000 c.p., and a full complement of arc lamps.

Southampton.—The Works Committee of the Harbour Board reported at a meeting last week that the sub-committee stated that on the 26th October they witnessed the lifting and slewing of the electric crane with a weight of three tons in the slings, and afterwards the crane was put through severe tests, both as to speed and weight, and both lifting and slewing. All the tests required by the specification were carried out in a satisfactory manner, the speed being in excess of that specified. A report was also received on the subject from Mr. Aldridge, with a table of results. Alderman Cleveland expressed his great pleasure at hearing so satisfactory a report of the electric cranes, in which he had taken so great an interest, and had determined to look after the Harbour Board on the matter. He hoped the second crane would achieve an equal success, and then they would have appliances which, as far as his knowledge went, were not possessed by any other port in the kingdom.

The Royal Exchange.—The Lord Mayor (Mr. Alderman Tyler), as stated in our last issue, performed the ceremony on the 23rd ult. of turning on the current in connection with the installation of the electric light at the Royal Exchange. There are four arc lamps in the quadrangle, each of 2,500 c.p., and an incandescent lamp of 100 c.p. in each of the four corners of the ambulatory. The current is supplied by the City of London Electric Lighting Company, Limited. In consequence of the building being washed down periodically by the fire hose the cables attached to the mains have been specially made concentric and lead covered, and all the joints are enclosed in cast-iron boxes filled in with hot bitumen. This is the first time that the interior of the Royal Exchange has ever been illuminated with artificial light, although great inconvenience has hitherto been experienced in foggy weather as a consequence. The installation has been carried out from plans and specifications prepared by Messrs. Shepherd and Watney, Leeds, the contractors being Messrs. J. G. Statter and Co.

Lighting at Islington.—The Special Electric Lighting Committee reported at a meeting of the Vestry last week that they had made enquiries for a site for the proposed electric lighting works. The committee thought that the Great Northern Railway Company's property in Eden-grove and Burnand-place would be suitable for the station. The land which the company were willing to sell covers an area of about 32,400 square feet. The committee were advised by the electrical engineer that three cartway entrances would be obtainable to the site, one from Eden-grove, one from Burnand-place, and one from Wellington-road; that engine rooms could be erected thereon capable of containing at least 11 sets of plant for incandescent lighting (allowing full room for slow-speed horizontal engines), and six sets for arc lighting; that ample accommodation would be available for offices, switch-room, workshops, coal stores, etc.; and that easy means of obtaining coal direct from trucks into the works could be secured. The committee recommended the Vestry to refer it to them to carry out the negotiations for the purchase of the site. The Vestry adopted the report of the committee.

Barnet.—The Electric Lighting Committee of the Local Board mentioned, at a meeting on the 15th ult., that it was of opinion, provided the electric light could be supplied by a company upon a satisfactory basis to the Board, or could be supplied by the Board upon a satisfactory commercial basis, that the town should be lighted by electricity. The committee further recommended, at a later meeting, that an advertisement should be inserted in the *Electrical Engineer* and another paper as follows: "The Barnet Local Board invite applications from companies or firms willing to take the transfer and to undertake and carry out the Board's guarantee by the Barnet Electric Lighting Act, 1893. Applicants are requested to state: (1) The system of lighting proposed, (2) the charge for lighting the public lamps, (3) the terms upon which and at what periods they would give the Local Authority the option of repurchasing the undertaking." This report was adopted. The advertisement was published in our last issue, and is also printed in the present number. The clerk was instructed to write to the Electric Installation Company, who had sent its men there, and acquaint them with what the Board proposed to do.

Lighting at Guildford.—We referred last week to a public meeting held to consider the introduction of electric light. At that meeting, it will be remembered, a considerable amount of support was offered, and a committee was appointed to make further enquiries and ascertain whether the amount required for the initiatory proceedings could be raised within the specified time during which a provisional order could be applied for. The committee, which was fully representative, decided that if £300 were subscribed in the way of "founders' shares" within the limit of the borough the order should be applied for in the usual way. This condition has been complied with, and formal notice to the Board of Trade has been given. The provisional order is asked to authorise the Holloway Electricity Supply Company, Limited, to supply electricity for public and private purposes within the borough of Guildford, in the event of a company being formed, but the Holloway Company will hand over their powers to the local one when the latter is ultimately constituted. There is great unanimity in Guildford as to the desirability of introducing a supply of electricity into the borough. If the Corporation can have inserted in the order a reasonable clause enabling them at some future time to buy up the company, no opposition may be expected from that quarter.

The Sunderland Tenders.—The sub-committee are now considering tenders for the station. Eight contracts are to be made for the laying out of the necessary plant, and the tenders sent in have puzzled the sub-committee which has the work in hand. There were 28 for Lancashire boilers, the prices ranging from £2,500 to £1,235. Contract No. 2 is for compound engines and dynamos, for which 16 tenders had been sent in, the figures ranging from £6,015 to £4,040. For motors, alternators, and switchboards there were 15 tenders, the highest being £3,000 and the lowest £1,100. No. 4 specification was for main switchboards, instruments, and connections. Here there were 19 tenders, varying in price from £1,350 to £575. For batteries there were seven tenders, the highest being £2,280 and the lowest £763. For insulated cables there were seven tenders, and for roadwork 15 tenders, but the total prices were to be ascertained on measurement. The eighth and last specification was for copper strip, and 11 tenders were sent in, the price per pound being 7½d. in the case of the highest and 6¾d. the lowest. One firm—Messrs. Parsons and Co., of Newcastle-on-Tyne—tendered to do the whole of the work on a system of their own for £19,044. The great diversity of prices so bewildered the committee that they decided to send the tenders to Prof. Kennedy to go through them and report on the matter.

Lighting at Bolton.—A lecture on "Bolton's Electric Supply" was delivered last week at the Technical School by Mr. J. H. Rider, M.I.E.E., electrical engineer to the borough. The chair was occupied by Alderman Miles, J.P., chairman of the Gas and Electricity Committee of the Corporation. The Chairman, after paying a compliment to the abilities of Mr. Rider, said the Gas Committee had determined that they would spare neither pains nor expense to have a first class installation for the town. Mr. Rider then delivered his lecture. He explained the direct and alternating current systems, and gave illustrations of the advantages of incandescent lamps. He also explained and practically illustrated the principle of the arc light. With regard to the cost of the illuminant, he said that many people did not seem to understand the list of charges sent out by the Corporation. They proposed to charge for the light by the indications of a meter similar in appearance to an ordinary gas meter, but instead of charging so much per cubic foot, they would charge so much per Board of Trade unit. There would be a differential system of charging. The proposed sliding scale of charges ranged from 5½d. to 8d. per unit, the idea being to give rich and poor consumers an equal chance of obtaining the light. A vote of thanks was passed to the lecturer, and also to the Chairman, who said it was hoped in a few months that the installation would be completed.

Derry.—The project undertaken by the Corporation for the street illumination of Derry with the electric light is now nearing completion. It is understood that, unless some unforeseen circumstance occurs to interfere with present progress, the promoters are confident that the greater portion of the city will be electrically lighted before Christmas. The new generating station buildings are situated between Strand road and the Quay. One engine has been already put in position, and the makers state that in less than a fortnight they will be able to test it under steam. This engine is capable of working up to 140 h.p. The flywheel is 8ft. in diameter, driving two dynamos by belts. Only one third of the area of the yard at the station is occupied by the buildings for the street lighting, the remainder being reserved for the house to house lighting scheme should the citizens express a desire to take it up. The machinery room is 60ft. long by 40ft. wide, open to the ridge a clear height of 32ft. Thirteen feet above the floor level runs an overhead travelling crane for lifting any part of the machinery. The boiler house is built to contain two Lancashire boilers, each 26ft. long and 7ft. in diameter, and each capable of generating steam for 200 h.p. with average coal and draught. At the back of the boiler is fixed a Green fuel economiser, consisting of 96 pipes, through which the water is passed before entering the boilers. The chimney stack is 125ft. high. The dynamos are ready for delivery, but it is not considered desirable to have them on the spot until the engine and flooring are complete. The cables are now completed in two circuits. There are in all 17 miles of cables already laid in the city and Waterside. A start has been made on the west section. Over 100 street pillars have been erected in the various thoroughfares, and the lamp carriers, ready for the lamps, have been fixed on most of them. A number of the lamps are already on the spot complete for erection upon the pillars. All the electrical work in connection with the scheme is being carried out by Messrs. Siemens Bros. and Co., Limited, under the personal supervision of their engineer, Mr. W. A. Collings. The lamp pillars are being supplied and all mechanical work satisfactorily performed by Messrs. Alex. Brown and Son, Derry. The contract for the station buildings, chimney, boiler setting, foundations, etc., is in the hands of Messrs. Matthew M'Clelland and Co. The designs have been furnished by Mr. R. Eccles Buchanan, C.E., architect, Shipquay street; while Mr. H. W. Blake watches the interests of the Corporation as their consulting engineer.

Dundee.—A representative of a Dundee paper has had an interview with Mr. Matthew Buchan, who has just returned from America, where he has been engaged as an electrical engineer and tramway expert with the chief electrical companies in the United States. Mr. Buchan is a native of Portobello. Previous to going to America, he had five years' experience in England. During the five years he was in the States he was connected with the Westinghouse, the Edison, and latterly with the Thomson Houston Companies. He studied electricity as a motive and lighting power, and he has now resolved to remain in this country and establish himself as an electrical engineer. Mr. Buchan said that if electricity were supplied to the houses it could be utilised as a motor for domestic purposes. In Dundee there were many persons who would utilise it in that way if it could only be supplied at a cheaper rate. The central station could easily supply electricity for such purposes if the consumers would take it during the day, as they had a number of machines standing idle all day. If that were done, motors could be supplied by the company which would drive sewing machines and other domestic machines. In America this system of utilising electricity is being rapidly developed. With regard to tramways, the speaker stated that a gradient of about 10 per cent. could fairly be worked, if it was not necessary to stop on the incline. He preferred the overhead wires to the underground conduit system. Asked whether there was any danger from the overhead wire breaking, he stated that such accidents rarely occurred. In America it was the general rule to run at a potential of 500 volts, but that could be reduced for safety to 400 volts. A shock of 500 volts might almost kill a man, but it did not do it as a rule. At 400 volts there was no danger to human life. The danger would thus be very small. The objection to the underground conduit system was the trouble caused by the conduit in which the wire is laid being filled with dirt and dust. When heavy rain fell the conduit was apt to be flooded. Wet lessened the power of the electric current, and if the channel was flooded the traffic would be interrupted till it was cleared. The lines at present in existence in Dundee would be suitable for electric cars. The electric cars would be a great saving of horses, and they could do away with the unsightly and dangerous steam cars. The cars generally ran in America at a speed of about six or seven miles an hour in the city, but when they got into the suburbs where they had a clear country he had seen them spinning along at the rate of 20 miles. Mr. Buchan could not speak positively regarding the financial results of the electric system in America. One company he knew paid a dividend the first year, and one thing was certain, if they did not pay the Americans would not be extending them all over the country.

Lighting of Harrow.—As stated in our last issue, the Local Board are applying for a provisional order. Before this decision was arrived at, the matter was fully discussed by the members of the Board. At a recent meeting the Chairman called attention to a piece of land near Harrow Pond which had been acquired. At the time of the purchase it was thought to erect an electric light station, but there was then no thought of public baths. Mr. Pitcairn presented the report of the committee appointed to deal with the subject. The report stated that the committee, in accordance with the authority given them to employ an electrical engineer, instructed Mr. W. C. C. Hawtayne, of 3, Princes'-mansions, Victoria street, S.W., to furnish them with a report, and at the same time the clerk put himself into communication with the school authorities with a view to ascertaining whether the light would be adopted by the masters and in the school buildings. Mr. Hawtayne had sent in his report, in which he dealt fully with the subject, and basing his figures on the assumption that all the public lamps in the district would be lit, that the light would be taken by the masters in their houses and in the school buildings, and that 1,000 lamps would be taken by other private consumers in the compulsory area suggested by him, Mr. Hawtayne advised the committee that if the light was supplied at 8d. per Board of Trade unit the experiment might be expected to result in a surplus of revenue over expenditure of £150. The best site for the station was considered by Mr. Hawtayne to be land adjoining the depôt of the Metropolitan Railway Station at Pinner-road, as coal could be cheaply delivered there, but it was not available for purchase. It had occurred to the committee and to Mr. Hawtayne that Harrow Pond was from its central position a most convenient site, and here he proposed that the station should be established. Another reason for choosing Harrow Pond as a site was the question of public baths. There had of late been a feeling that public baths were desirable. The report stated that if it could be shown that public baths could be established and maintained at a reasonable cost, the committee thought no more suitable place could be found than at Harrow Pond, and if they were constructed in conjunction with an electricity supply station a great saving would be effected in the cost of the original construction, and still more in the annual cost of each undertaking. Mr. Hawtayne estimated that the annual saving in the case of the electricity supply station in conjunction with public baths would be a further £150. The committee therefore suggested that if the Board desire to proceed with the electrical work, plans should be obtained which would make it possible to erect the station either in conjunction with public baths or to admit of public baths being added hereafter. The committee stated that if the Board did not take up the question of the electric light it would be possible for Messrs. Joel and Co., who had already given notice of their intention to apply for a provisional order, to obtain it. The committee did not think it would be advisable to give them this opportunity, but were strongly of opinion that if there are reasonable prospects of a profit being made by electric lighting, the Board should secure these advantages for the ratepayers, and keep as far as possible the control of the streets. The committee recommended that a fee of £25 should be paid to Mr. Hawtayne in respect of his enquiries and report; that it be left to the committee to offer a premium of £25 to architects for the best plans for an electricity supply station, in conjunction with public baths, to be constructed upon the Harrow Pond and Gardens site, and that a provisional order should be applied for. These recommendations, as already mentioned, have been adopted.

Elmore's French Patent Copper Depositing Company, Limited.—Under a winding up order granted on July 8 against this Company, a statement of affairs has been submitted by the secretary and is concurred in by Major Jones and Sir J. D. Mackenzie, the directors. The gross liabilities of the Company are returned at £140,460, of which £53,458 are expected to rank, and there do not appear to be any assets available for the unsecured creditors. As regards contributories, the total deficiency is £298,290. From the observations of the official receiver and provisional liquidator (Mr. C. J. Stewart) it appears that the Company was incorporated on September 10, 1890, and was formed for the purpose of acquiring and working in France certain French patents relating to process for manufacturing copper articles discovered by Messrs. F. E. and A. S. Elmore and patented by them in 1885. In 1889 a company was formed to acquire and work their patents relating to Great Britain and Ireland. The official receiver states that at the date of the formation of the Company, Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited, were the owners of all the existing patents for other parts of the world relating to the Elmore copper process. On September 4, 1890, the Foreign and Colonial Company agreed with Woodhouse and Rawson United, Limited, now in liquidation, that the latter should form a company for the purpose of acquiring the patents for France relating to the same process in consideration of £15,000 in cash and certain premiums. The benefit of this agreement was transferred by Woodhouse and Rawson

United, Limited, on September 9, 1890, to the Phœnix Trust, Limited, which company appears to have actually promoted the French Elmore Company, Limited. On the following day the French Elmore Company agreed to purchase from the Foreign and Colonial Company the French patents above mentioned for the sum of £83,500 in cash, £66,500 in fully paid-up shares, and a premium of 10s on each share subscribed for by the public. This agreement was duly carried out, the purchase price paid to the vendor company being £66,500 in shares and £116,875 in cash. A prospectus was issued to the public in September, 1890, containing extracts from various reports speaking in favourable terms of the Elmore copper process, and the whole of the original capital of £66,750 offered to the public was at once subscribed for and allotted. It was also pointed out that, after payment of the purchase money to the vendor company, the sum of £30,000 would be left for working capital. On October 1, 1890, M. Secrétan was appointed manager of the company in France, and shortly afterwards a committee was appointed to act with him. In November, 1890, the Board resolved that it was advisable to erect works in the North of France on a much larger scale than had been contemplated at Bellegarde, and in the following month it was decided that 37 acres of land at Dives, near Havre, should be acquired for that purpose. The official receiver after giving some further details as to the operations of the Company, states that the whole of its monetary resources were exhausted in connection with the establishment of the works in France, and it was unable to pay the interest falling due upon the debenture stock on November 1, 1892. Under the powers contained in the debentures Mr. J. H. Duncan was appointed receiver on behalf of the holders. The Company being unable to continue its business, the shareholders subsequently resolved that it should be wound up voluntarily. Mr. F. W. Pixley being appointed liquidator. The official receiver avers that no dividends have been paid on the ordinary shares, but a dividend of 10 per cent. on the preference shares, which was guaranteed for one year by the Foreign and Colonial Company, appears to have been paid by that company. The failure of the Company is attributed by the secretary to the fact that the works were undertaken on too large a scale in proportion to the capital. It was intended to raise more capital later when the merits of the Elmore copper process had been proved, but this had not been done by the time the additional capital was required, and consequently the preferential shares were not subscribed for to the extent that had been hoped.

PROVISIONAL PATENTS, 1893.

NOVEMBER 20.

22140. **Improvements in incandescent electric lamps.** William Shaw Smith, 20, Tanfield chambers, Bradford.

22184. **Regulating apparatus for electromotors.** Charles Denton Abel, 28, Southampton buildings, Chancery lane, London. (Berliner Maschinenbau Aktien Gesellschaft vorm. L. Schwartzkopff, Germany.)

22186. **Improvements in lock and block electric apparatus.** Edward Tyer, 28, Southampton buildings, Chancery lane, London.

22195. **An improved permanent magnet.** Arthur Thomas Collier, 11, Southampton buildings, Chancery lane, London.

22214. **Improvements in glass bulbs relating to incandescent and other lighting.** George William Pridmore and Thomas John Sturgeon, 2, Broad street buildings, Liverpool street, London.

NOVEMBER 21.

22253. **Automatic railway electric signals.** Charles Hamlin Bradrick and Burton Aldest Karr, 154, St. Vincent street, Glasgow. (Complete specification.)

22255. **Improvements in signal telegraphy.** Hugh Donald Fitzpatrick, 70, Wellington street, Glasgow. (The Boughton Telephotos Company, United States.) (Complete specification.)

22274. **Improvements in primary electric batteries.** Alfred Vincent Newton, 6, Bream's buildings, Chancery lane, London. (Alfred Nobel, France.)

22304. **Improvements in or connected with trolleys for electric railways.** James Trezevant Fuller, Norfolk House, Norfolk street, Strand, London.

22311. **Improvements relating to storage batteries.** Edward Preston Usher, 45, Southampton buildings, Chancery lane, London. (Complete specification.)

22312. **Improvements in storage batteries.** Edward Preston Usher, 45, Southampton buildings, Chancery lane, London. (Complete specification.)

NOVEMBER 22.

22335. **The electrical and explosive method for extinguishing fires.** John Worthington and Robert Parkinson, Post Office-chambers, Coronation street, Blackpool.

22359. **An improved electrical detachable joint.** Frederick King and William Phillips Mendham. The Western Electrical Works, Narrow Wine street, Bristol.

22363. **An improved multiple-circuit microphonic transmitter.** Frederick Thomas Trouton, Caerleon, Killiney, co. Dublin.

22366. **Improvements in phonographs.** William Henry Dunkley, 79, Jamaica row, Birmingham.

22379. **Improvements in charging primary batteries.** Samuel Miller and Charles James Grist, 1, Langton-cottages, Melbourne square, Brixton, London.

22395. **Improvements in electric systems and apparatus.** Percy Edward Pownall and Robert Bolger Pownall, 55, Chancery lane, London.

NOVEMBER 23.

22437. **An improved electrical measuring instrument.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley and Alfred Soames, 16, Red Lion street, Clerkenwell, London.

22438. **Improvements in pivoted electrical measuring instruments.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley and Alfred Soames, 16, Red Lion-street, Clerkenwell, London.

22439. **Improvements in electrical measuring instruments.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 16, Red Lion street, Clerkenwell, London.

NOVEMBER 24.

22519. **Improvements in clips for electric conductor casing.** Charles Darrah, of the firm of Baxendale and Co., and Charles Cartwright Metcalfe, 70, Market street, Manchester.

22562. **Improvements in or connected with electrical signalling apparatus.** Thomas Davis and Edward Davis, 6, Lord-street, Liverpool.

22570. **Improved apparatus for working railway switches by means of electrical energy and for signalling in connection therewith.** Siemens Bros. and Co., Limited, 28, Southampton buildings, Chancery lane, London. (Messrs. Siemens and Halske, Germany.)

22584. **Improvements in means for fixing fuses in electric circuits.** Richard Ernest Holdom and Herbert Smyth, 37, Chancery-lane, London.

NOVEMBER 25.

22594. **Improvements in arc electric lamps.** William James Davy, 161, Huddleston road, Tufnell-park, London. (Complete specification.)

22651. **Improvements in electric lamps and shade holders.** Leon Thomas Buckler and Thomas Clarke, 6, Lord-street, Liverpool.

22674. **Improvements in or relating to electric regenerative batteries or accumulators and in porous cells therefor.** Reginald Haddan, 18, Buckingham street, Strand, London. (Henry Riguelle, Belgium.)

SPECIFICATIONS PUBLISHED.

1887.

9729. **Electric converters.** Thompson. (Westinghouse.) (Second edition.)

1890.

2945. **Electric secondary cells.** Laurent-Cély and Timmis. (Second edition.)

1891.

11519. **Electric cells.** Le Sueur. (Second edition.)

1892.

19019. **Electric conductors.** De Solome.

20445. **Electric meters.** Raab.

22261. **Electric arc lamps.** Hills.

23101A. **Galvanic batteries.** C. A. J. H. and H. E. R. Schroeder.

24009. **Pipes for electric cables, etc.** Crompton and Chambers.

1893.

17564. **Electric accumulators.** Koch.

18323. **Electric batteries.** Leigh. (Chevallier.)

18480. **Dynamo-electric machines, etc.** Rahner.

18524. **Indicators for telephone stations, etc.** I. R. and W. F. Burns.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¾
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13
Electric Construction	—	1¾
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¾
	3	4½
London Electric Supply	5	1
Metropolitan Electric Supply	—	7¾
National Telephone	4	4¼
St. James', Pref.	—	8½
Swan United	3½	3¼
Westminster Electric	—	5¼

NOTES.

Bills.—No less than 27 electric lighting Bills are being promoted for the next session.

Hammersmith.—It is intended to light with both gas and electricity the new town hall to be built at Hammersmith.

No Gas Wanted.—The City Commissioners of Sewers decided on Tuesday to remove the gas standards in the City streets.

Long-Distance Telephony.—The telephonic service between Denmark and Sweden was formally inaugurated on Tuesday by King Christian and King Oscar.

Bristol.—The central station is now in operation, current being supplied to both public lamps and private customers. Application has been received for 14,000 lamps.

The "Medical Battery" Company, Limited.—The hearing of the charges against the officials of this company was resumed on Tuesday and Wednesday and was again adjourned.

The Gas Met him Half-Way. — A Carlisle man found a leakage of gas, in the usual manner, a few days ago by applying a light. There is no such danger with the electric light.

Rising in the Main.—Not only is gas rising in the main, but also in price in different towns. This fact is having a tendency to bring the electric light more prominently forward.

St. Paul's Cathedral to be Lighted.—The Restoration Committee of St. Paul's appointed a sub committee on Tuesday, to enquire as to the cost of introducing the electric light into the cathedral.

Board of Trade Rules.—We understand that a meeting of those members of the Electrical Section of the London Chamber of Commerce interested in these rules will be held at the offices of the Chamber of Commerce to-day.

International Exhibition.—The mayors of the leading boroughs have received a circular stating that a committee has been formed to promote a scheme for holding in London during 1896 or 1897 an international exhibition on a large scale.

Society of Arts.—On Monday the third Cantor lecture on "The Art of Book and Newspaper Illustration," by Mr. Henry Blackburn, will be delivered. On Wednesday a paper will be read by Mr Lewis H. Isaacs on "Carriage-way Pavements for Large Cities."

Traction at Poole.—As mentioned in our issue of the 17th ult., a scheme is being promoted for the construction of an electric tramway between Poole and Bournemouth, and for the purpose of utilising the supply station for furnishing electric light in the neighbourhood.

Train-Lighting.—The penny-in-the-slot system was introduced on Sunday in a train on the Richmond branch of the District Railway. In each carriage are four electric lamps, which can be turned on when a passenger puts a penny in the slot. The light burns for 30 minutes.

Traction at Llandudno.—As mentioned in a previous issue, it is proposed to construct an electric railway up the Great Orme's Head. Last week, under the auspices of the Llandudno Literary Society, a public discussion took place on the project, and a resolution in favour of it was carried.

The Institution.—It may be as well to remind our readers that the annual general meeting, as mentioned last week, will take place on Thursday next. After the ordinary business has been disposed of, the paper on "The Electrical Transmission of Power from Niagara Falls" will be further discussed.

Why Automatic Meters were Adopted.—A correspondent suggests that the fact that the electric light has become so much in vogue in large establishments has doubtless induced the Liverpool Gas Company to adopt the automatic meter system with the object of retrieving some of the lost consumption.

Lightning Expresses Unbearable. — It appears that the physical strain upon the drivers and stokers of high-speed trains in the United States is so considerable as to tell very severely upon the health of the men. This seems to be another point adverse to the lightning express railway service proposed by Mr. Behr.

New Book.—Signor Guido Castagneris has written a work upon "Electric Railways and Tramways," which is just published from the offices of our contemporary *L'Elettricita*. Under the exact title of "Tramvie e Ferrovie elettriche," this book contains 430 pages and some 200 illustrations, but nothing very new in the way of substance.

Switches and Switchboards.—We have received a copy of the price-list of switches, switchboards, and fuse-boards issued by Munro's Electrical Manufacturing Company, Limited, of 9, Holland-place, Glasgow. The company have supplied complete switch and fuse boards, among others, to various corporations, railway companies, colleges, etc.

Electric Lighting.—Mr. E. Eugene-Brown, M.I.E.E., of Messrs. J. H. Holmes and Co., read a paper on "Electric Lighting," before the Northern Architectural Association, on the 29th ult. The author described the various systems of electric lighting, explained the work and measurement of currents, and exhibited lamps, sections of cables, electric light fittings, etc.

Those Loving "Couples."—The sub-editors—no! assistant-editors—of all our electrical contemporaries are on the war-path. In their issues of the 1st inst. our contemporaries write of "installation couples." It would be interesting to learn whether they were single or married. If the latter, a good "installation couple" (insulated cable) might occasionally come in handy.

The Engines were not Detrimental.—The award has been made by Mr. H. T. Steward in the arbitration in connection with the alleged damage to the Monte Carlo Hotel, Leicester-street, by the electric lighting engines of the Empire Theatre. Damages to the extent of £2,000 were claimed, but the award is in favour of the Palace Company, M. Guffanti, the claimant, having to pay all costs.

Magnetic Counter-Thrust Bearing.—The name of Tesla goes of course a long way in fathering or fostering a proposal, and hence some notice may be taken of an idea said to have received the approval of that well-known scientist. There is no doubt some amount of power-loss incurred by the use of ordinary thrust bearings employed on ship screw-shafts; but whether this end thrust can be satisfactorily overcome by a magnetic pull in the opposite direction is, to say the least of it, undecided from actual results.

City and Guilds of London Institute.—Sir R. Webster, Q.C., M.P., presented at the Goldsmiths' Hall on Wednesday evening the prizes and certificates awarded in connection with this institution. The Lord Mayor presided, and amongst those present were Sir W. Prideau, Prof. W. C. Unwin, Prof. Silvanus P. Thompson, Mr. J. C. L. Sparkes, Sir Philip Magnus, Mr. C. W. B. Burdett,

Sir F. Bramwell, Mr. E. L. Beckwith, Mr. George Baker, Mr. J. Diggle, Sir F. Abel, Mr. W. Bousfield, and Mr. Alderman and Sheriff Moore.

Students of the Institution.—A meeting of the students of the Institution of Electrical Engineers will take place on Friday, the 15th inst., at 8 o'clock, at 28, Victoria-street, Westminster. A paper on "The Brightness of Light: its Nature and Measurement," by Messrs. J. M Barr and C. E. S. Phillips, will be read, and a letter concerning the premium offered to students by the Institution will also be presented.

Hampstead-Charing Cross Railway.—The Bill promoted by the Charing Cross, Euston, and Hampstead Railway Company, referred to in our last issue, is to authorise the compulsory purchase of additional lands in connection with the Company's authorised stations, subway for foot-passengers, and works; or for new station or stations, or subways for foot-passengers; easements under roads; provisions as to sale of surplus lands; exemption from operation of Section 92 of the Lands Clauses Consolidation Act, 1845; amendment of Company's Acts, etc.

Telephony in Germany.—It appears that the number of telephone stations in Germany, which was only 1,504 in 1881, had increased at the beginning of this year to 63,558, of which Berlin had no fewer than 17,424, with over 20,400 miles of lines. The inter-urban telephonic service is also increasing very rapidly, and there were at the beginning of the year 310 long-distance telephones, with 14,280 miles of lines, the longest direct line being that between Berlin and Breslau, which is nearly 200 miles. Since then the Cologne-Berlin line, 293 miles long, has been put into service.

Writing on Trees with Search-Lights.—A demonstration was given on Saturday at the Cardiff Town Hall to test the utility of search-lights in connection with sign-writing. Captain Ronald Scott, M.I.E.E., supplied the machinery and conducted the experiments. The current was generated by means of a dynamo worked at the rear of the Town Hall. Taking alternately for a background the highest buildings in the vicinity, trees, and steam, by means of slides after the pattern of those used in magic lanterns, local crests, words, and faces were thrown upon those objects. Thousands of persons enjoyed this novel spectacle.

Propagation of Electromagnetic Waves.—Before a meeting of the Bradford Scientific Association a few days ago, Dr. Riley (president) introduced the subject of the "Propagation of Electromagnetic Waves." He referred to the recent researches of Dr. Hertz, of Vienna, who proved experimentally that the waves are transmitted with a velocity of about 185,000 miles a second. In conclusion, it was pointed out that light-waves were undoubtedly electromagnetic waves, and that the electromagnetic theory of light propounded by the late Prof. Clerk Maxwell had received splendid confirmation from the brilliant achievements of Dr. Hertz.

Tunnel-Driving by Electric Motors.—It is expected that the improvements made in drilling and quarrying machinery during the last few years, especially by the introduction of electric power, will enable the proposed Simplon tunnel to be constructed at a cost and rate which will place its predecessors in the shade. Motive power is now easily obtained from water in the Swiss mountainous districts, and the facility with which electric power can be transmitted renders the site of the generating station a matter of small moment. Five and a half years is the stipulated period for completing this tunnel, which it has been decided to carry out.

Breakdown of a Supply Station.—One of the most extraordinary causes of stoppage in the supply from a generating station is that which is reported from a country town in the United States. The boiler feed supply is obtained from a small river apparently well populated with small crabs. A number of these got into the feed pipes and effectually choked them, so that shortness of water led to a shut down and stoppage of traffic. The two morals to be drawn are: first, the importance of a grid at the feed inlet; second, the popularity of electric traction even in country places.

The "O. E." Electricity Meter.—This meter, which is adapted to all the requirements of electric supply, forms the basis of an excellent wall catalogue or list just issued by Mr. Joseph Edmondson, of Hey-street, Longside lane, Bradford. The catalogue, in addition to giving particulars of the "O. E." electricity meter, contains details concerning the conductivity, resistance, and fusing point of different metals and alloys and the effect of temperature on resistance per cent. per degree Fahrenheit; also the diameter, current capacity, resistance at 60deg. F. per 1,000 yards, and weight per 1,000 yards of single wire, and of 7, 19, 37, 61, and 91 strand cables.

The British Association. The council of the British Association have made the following nominations as presidents of sections at the Oxford meeting in August next: Mathematical and Phyiscal Science, Prof. A. W. Rücker, of the Science and Art Department; Chemistry, Prof Harold Dixon, of Owens College; Geology, Mr. L. Fletcher, Keeper of the Department of Minerals, British Museum; Biology, Dr. T. B. Balfour, Professor of Botany at Edinburgh University; Geography, Captain W. L. Wharton, Hydrographer to the Admiralty; and Anthropology, Sir William Flower, Director of the Natural History Department of the British Museum.

To Local Authorities.—From the Board of Trade returns and elsewhere it is known that many local authorities have obtained or intend obtaining provisional orders, while few have actually entered upon the practical work. A movement is on foot—organised by Mr. H. Scholey, of 22, Paternoster-row—to provide lecturers, who shall be at once capable and unbiassed, to put before local authorities and their constituents the true position of electric lighting and power transmission from a commercial point of view. Lectures will be given, illustrated with diagrams and experiments, in any town upon the payment of a reasonable fee and expenses. We understand that several capable lecturers have agreed to the scheme, which ought to be useful.

The Pacific Cable.—The *Canadian Gazette* states that in the Queensland Assembly on October 11, during consideration of the estimates of the Postmaster General's department, Mr. Dickens asked whether the Government were prepared to make an arrangement with Sir John Pender for a reduction of the cable rates between Queensland and London. Sir Thomas McIlwraith, the Premier replied that the Government declined to be a party to the monopoly of the Eastern Extension Telegraph Company. The policy of the Government was to have a free hand and to subsidise a second cable. This led to a discussion of the question of subsidy to the New Caledonian cable, and, in reply to a question, Sir Thomas McIlwraith stated that the agreement between Queensland and the French company provided for the payment of £2,000 per annum for 30 years.

France and Telegraphy.—A commission has been formed by the French Posts and Telegraphs Department to investigate the question of the international telegraphic

communications of France. The work of the commission consists in drawing up a programme of all the telegraphic communications, the establishment of which is deemed necessary in the interest of France, the estimation of the cost of the various lines, and the order in which the works should be carried out. After an exchange of views at the first assembly of the members of the commission, in the course of which it was declared that it is now more imperiously necessary than ever to organise a system of French submarine telegraphic cables, the commission instructed a sub-commission to elaborate a comprehensive plan, and to prepare certain projects, the carrying out of which was regarded as particularly urgent.

The Electric Light Saved Money.—In giving the toast of "Prosperity to the Association" at the twenty-eighth annual dinner of the Leeds Association of Engineers on Saturday, Mr. Reginald Wigram, who occupied the chair, observed that an important development of the year had been the progress made in the use of electricity. Experimentally, it was shown at the Frankfort Exhibition that they could produce electricity at the Falls of the Rhine and light Frankfort with it. That certainly pointed to a diminution in the use of coal. Why should not Leeds have water power brought to it by electricity from a point up in North Yorkshire 50 or 60 miles off? He stated that in certain works at Bolton as much electric light might be had for 4s. 4d. per annum as of gas for 5s. 6d. a year, and that in the Exchange Restaurant in Manchester the use of electricity saved £800 a year.

Wrought-Iron and Steel Tubes.—Judging from the new catalogue just issued by Messrs. James Menzies and Co., of 6, Lime street-square, E.C., and of the Phœnix Tube Works, Dalmarnock Bridge, Glasgow, the company seem to cover the whole of the ground comprised in the category of the manufacture of wrought-iron and steel tubes for practically all purposes. For instance, on turning the first pages of the pamphlet, one finds references to standard wrought-iron tubes for gas, water, and steam purposes, together with diameters, prices, and weight per foot in pounds for each particular object, and supplemented with details of short pieces, connections, bends, and other fittings. Then we come to lap-welded iron and steel tubes for locomotive, marine, and stationary boilers; next boring tubes for artesian purposes, Menzies patent flange joint and tubes for hydraulic purposes, and, finally, rain-water pipes and fittings.

Dust Destructors for Lighting.—In a lecture delivered the other evening before the members of the Yorkshire College, at Leeds, on the utilisation of town refuse, Mr. C. Rawson, F.C.S., observed that the results of a test made at Ravensthorpe showed the steam-producing power of refuse to be one-third that of good average coal. The amount of steam power thrown away was therefore considerable, and the best way to utilise the refuse was by treating it in a destructor, and applying the fuel portion to the generation of steam for driving dynamos. The refuse of Leeds, he remarked, would yield steam equivalent to 1,764 h.p. continuously day and night. The quantity of refuse to be disposed of in that city was estimated at 130,000 tons per annum, and assuming it to be of the same quality as that tested at Ravensthorpe, it would yield as much steam as 17,000 tons of good average coal. In like manner the refuse of Bradford should produce 948 h.p. continuously.

The Northern Society of Electrical Engineers. A new institution bearing this title has just been formed, with headquarters in Manchester, for the purpose of holding meetings for the promotion of electrical science and its commercial and other applications, and for social intercourse between members. The society has not been founded with any view of rivalry or opposition to the existing Institution of Electrical Engineers, but simply to enable members of the profession who are unable to attend meetings in London to do so in the provinces, and at the same time to become better acquainted with each other. We are informed that a large number of gentlemen has already joined the society, and that invitations have been posted to members of the profession within range of Manchester inviting their co-operation. At present it has been decided to hold the meetings in Manchester, but it is expected that at an early date gatherings will be arranged for at other provincial towns. Mr. John Darney, of 102, Portland-street, Manchester, is the hon. secretary.

Royal Institution.—The following are the lecture arrangements before Easter: Prof. Dewar, six lectures (adapted to a juvenile auditory) on "Air: Gaseous and Liquid"; Prof. Charles Stewart, nine lectures on "Locomotion and Fixation in Plants and Animals"; the Rev. Canon Ainger, three lectures on "The Life and Genius of Swift"; Mr. W. Martin Conway, three lectures on "The Past and Future of Mountain Exploration"; Prof. Max Müller, three lectures on the "Vedânta Philosophy"; Prof. W. H. Cummings, three lectures on "English Schools of Musical Composition" (with musical illustrations); the Right Hon. Lord Rayleigh, six lectures on "Light," with special reference to the optical discoveries of Newton. The Friday evening meetings will begin on January 19th, when a discourse will be given by Prof. Dewar on "Scientific Uses of Liquid Nitrogen and Air"; succeeding discourses will probably be given by Mr. A. P. Graves, Mr. T. J. Cobden-Sanderson, Prof. W. F. R. Weldon, Prof. Silvanus P. Thompson, Prof. John G. McKendrick, Dr. W. H. White, the Right Hon. Lord Rayleigh, and other gentlemen.

The Oscillation of Electric Sparks.—Prof. C. V. Boys, F.R.S., lectured on Monday evening at the London Institution on the subject of "When and Why an Electric Spark Oscillates." The lecturer, by a series of mechanical illustrations corresponding with their electrical equivalents, showed how when an electrical current passed round any circuit whatever through a piece of wire the space around that wire was magnetised. When an electrical current had magnetised the space around itself, and one tried to stop the current, the magnetism which had been induced could not suddenly cease to exist; but in dying out it urged the current on in the direction in which it was going, and was able to introduce a surprising effect. The magnetic force developed by an electrical current was able, if one tried suddenly to stop it, to give to the current the effect of momentum. There was no momentum in electricity by itself, but only in virtue of the fact that it magnetised the space round it. Electrical resistance and mechanical resistance were analogous to one another. Just as in the case of sound-waves, which travelled at a definite rate, so, in the case of electromagnetic oscillations, they took place in the medium connecting two discharge circuits with the waves. The electromagnetic waves which were thus set up did not travel slowly, but at the rate of about 187,000 miles a second.

Lighthouse Communication.—In the House of Commons last week Sir J. Long asked the Postmaster-General whether he would state what number of lighthouses on the coasts of the United Kingdom now had electrical communication, and to what further number it was proposed to extend such communication. In reply, Mr. A. Morley said that the number of lighthouses on the coasts of the United Kingdom which had been provided with electrical communication was 22. This number included Lundy

Island, Fair Isle, and the Gunfleet pile lighthouse. The Royal Commission on Electrical Communication with Lighthouses, etc., had recommended that communication be also extended to Caldy Island, the Tuskar, and the Fastnet. They had not yet reported as to any further extension. Sir J. Leng then asked the President of the Board of Trade what floating lightships now communicated with the Telegraph Department by electric cables, and whether it was intended to lay down electric cables to other lightships. Mr. Mundella observed that the work of connecting with the shore by electric cable the North Goodwin and the Kentish Knock light-vessels was being proceeded with as rapidly as practicable. He hoped they would be completed during the present financial year, and this, with the Gunfleet lighthouse, would exhaust the amount placed at his disposal for this purpose.

An Opportunity for Ladies.—"The great fall in the price of lamps," remarks a lady writer in the *Pall Mall Gazette*, "has led to the increased popularity of electric lighting, but the difficult problem to solve is where to place the light. So many people object to ceiling lights, and yet the greater part of Lord Salisbury's house at Hatfield is illuminated in this way. The chief objection to ceiling lights is that they are not pretty, and are difficult to shade, but there can be no doubt that this is the only way to light up large rooms. Branches from the wall only partially illuminate, and when properly shaded leave the rest of the room in darkness. Lamps are excellent for reading or table purposes, but they altogether fail to light the walls, or the upper part of the room and so prevent pictures from being seen at all, unless, of course, they have special lamps fixed in front of them. There is a great chance for anyone who wants to earn a living by making a speciality of advising on this point, since so many rooms are entirely spoilt by the inartistic manner of arranging the lamps. Another question which is exciting much attention in the feminine mind is the shading of the electric light. In nine cases out of ten the whole effect is spoilt by defective shading. In the next electric exhibition it is to be hoped that some new ideas on this very important point will be forthcoming. At present the matter is in its infancy. Here, too, is another opening for women who want something to do. The field is boundless, and no capital is required."

Royal Society Medals.—Lord Kelvin presented medals to the following at the anniversary meeting of the Royal Society last week: The Copley Medal to Sir George Gabriel Stokes, F.R.S., for his researches and discoveries in physical science; a Royal Medal to Prof. A. Schuster, F.R.S., for his spectroscopic enquiries and his researches on disruptive discharge through gases and on terrestrial magnetism; a Royal Medal to Prof. H. Marshall Ward, F.R.S., for his researches into the life-history of fungi and schizomycetes; and the Davy Medal to Prof. J. H. van't Hoff and Dr. J. A. Le Bel, in recognition of their introduction of the theory of asymmetric carbon, and its use in explaining the constitution of optically active carbon compounds. At the same meeting the following officers and council were elected for the ensuing year: President, Lord Kelvin; treasurer, Sir John Evans; secretaries, Prof. Michael Foster, Lord Rayleigh; foreign secretary, Sir Joseph Lister; other member of the council, Prof. Isaac Bayley Balfour; Andrew Ainslie Common, LL.D., Andrew Russell Forsyth, Sc.D.; Richard Tetley Glazebrook; Prof. Alexander Henry Green; Sir John Kirk; Prof. Oliver Joseph Lodge, D.Sc.; Sir John Lubbock, D.C.L.; William Davidson Niven; William Henry Perkin, LL.D.; the Marquis of Salisbury; Prof. J. S. Burdon Sanderson; Adam Sedgwick; Prof. Thomas Edward Thorpe; Prof. William Augustus Tilden; and Prof. W. Cawthorne Unwin. The dinner of the society took place on the evening of the 30th ult.

An Imperial Train.—The Imperial Austrian train is described at some length in a recent issue of the *Organ fur die Fortschritte des Eisenbahnwesens*, and elevations and sectional plans of the different cars are given. The train is made up of eight cars in all, beginning with a baggage car, which also contains a special compartment for the conductor and the electric plant for lighting the train. This is followed by a servants' car, after which come in succession the car of the emperor, a car for the emperor's suite, a dining-car, a special kitchen car, another car for additional members of the suite, and finally a combination servants' and baggage car. The current for lighting the cars is furnished both by a dynamo and a storage battery, the arrangement being such that the latter comes into action if through any cause the operation of the dynamo should become interrupted. The storage battery is capable of supplying the 67 lamps with which the train is equipped for a period of 10 hours. The train is heated by steam furnished from a special heating boiler, and the cars are all supplied with ordinary hand, as well as vacuum and Westinghouse, brakes. It would appear from this that the Emperor of Austria is not, after all, very much better supplied with railway luxuries than is the ordinary commercial traveller upon our corridor trains running to Scotland, except on the one point of exclusiveness and choice selection as regards travelling companions.

Gas-Engines as Prime Movers.—The electricity supply station of Waukesha is not a very extensive one, but it possesses some features of considerable interest as regards the type of prime movers adopted. These latter are two in number, an Otto gas-engine and an ordinary steam-engine, each of 100 h.p. The gas-engine has two horizontal cylinders with very heavy flywheel and driving pulley on the crankshaft. A countershaft is also provided, and this too carries a pulley of great weight. The speed of the engine averages 160 revolutions a minute, that of the countershaft is 690 revolutions. Leather belting is used to connect the shafts, and either engine is arranged with friction-clutches, so that it may drive any of three dynamos—one 80-arc lighter, one 75-arc lighter, and a machine for incandescent lights to the number of some 600. One or two machines may be driven from either engine, or both may drive all three. As a rule, the gas-engine is set to drive one of the arc lighters and the incandescent light machine; then at the time when the public lighting comes on, the steam-engine is started and the load transferred—the gas-engine taking the street lamp load. The total output is too heavy for either engine, generally speaking; but whenever light enough for one only, the gas motor is always used for choice. Careful experiments with this plant at different times show, amongst other things, what is not altogether surprising—viz., that an increase in the load under normal conditions tends to considerably reduce the cost of working per horse-power hour—so far as the gas consumption is concerned.

The Royal Society Anniversary.—The anniversary meeting took place on the 30th ult., at Burlington House The president (Lord Kelvin), in the course of his address, said that not the least important of the scientific events of the year was the publication, in the original German and in an English translation by Prof. D. E. Jones, of a collection of Hertz's papers describing the researches by which he was led up to the experimental demonstration of magnetic waves. For this work the Rumford Medal of the Royal Society was delivered to Prof. Hertz three years ago by his predecessor, Sir George Stokes.

Faraday, with his curved lines of electric force, and his dielectric efficiency of air and of liquid and solid insulators, resuscitated the idea of a medium through which, and not only through which but by which, forces of attraction or repulsion, seemingly acting at a distance, are transmitted. The long struggle of the first half of the eighteenth century was not merely on the question of a medium to serve for gravific mechanism, but on the correctness of the Newtonian law of gravitation as a matter of fact however explained. The corresponding controversy in the nineteenth century was very short, and it soon became obvious that Faraday's idea of the transmission of electric force by a medium, not only did not violate Coulomb's law of relation between force and distance, but that, if real, it must give a thorough explanation of that law. Nevertheless, after Faraday's discovery of the different specific inductive capacities of different insulators, 20 years passed before it was generally accepted in Continental Europe. But before his death, in 1867, he had succeeded in inspiring the rising generation of the scientific world with something approaching to faith that electric force is transmitted by a medium called ether, of which, as had been believed by the whole scientific world for 40 years, light and radiant heat are transverse vibrations. Faraday himself did not rest with this theory for electricity alone. During the 56 years which have passed since Faraday first offended physical mathematicians with his curved lines of force, many workers and many thinkers had helped to build up the nineteenth century school of *plenum*; one ether for light, heat, electricity, magnetism; and the German and English volumes containing Hertz's electrical paper, given to the world in the last decade of the century, would be a permanent monument of the splendid consummation now realised. The Royal Society's *Transactions* and *Proceedings* of the last 40 years contained in the communications of Gassiot, Andrews and Tait, Cromwell Varley, De la Rue and Muller, Spottiswoode, Moulton, Plucker, Crookes and Grove, Robinson, Schuster, J. J. Thomson, and Fleming, almost a complete history of the new province of electrical science which has grown up largely in virtue of the great modern improvements in practical methods for exhausting air from glass vessels, by which we now have "vacuum tubes" and bulbs containing less than $\frac{1}{1000000}$th of the air which would be left in them by all that could be done in the way of exhausting (supposed to be down to 1mm. of mercury) by the best air-pump of 50 years ago. A large part of the fresh discoveries in this province had been made by the authors of these communications, and their references to the discoveries of other workers very nearly completed the history of all that has been done in the way of investigating the transmission of electricity through highly-rarefied air and gases since the time of Faraday.

Gas-Engines and Accumulators for Central Stations.—A pamphlet has been issued by the Hagen Accumulator Works dealing with "Municipal Electricity Works with Gas Motors and Accumulator Working." The *brochure* is discussed by Mr. F. Uppenborn in the *Elektrotechnische Zeitschrift* of the 1st inst. The author gives a curve—the mean curve of the gasworks in Dresden, Magdeburg, Bremen, Carlsruhe, and Hagen in Westphalia—showing the consumption during 24 hours of the day of heaviest demand in the year. The curve, which is made to correspond with the consumption in watts in the conductor, shows that the demand is very variable, and that the greatest consumption takes place at about 5.30 p.m. As is well known, gas motors work most favourably, from an economical point of view, at full load when the amount of gas used per horse-power hour is the lowest, whilst the consumption per working unit considerably increases at low loads. If now the electrical distributing mains are supplied direct from the generators without the use of accumulators, the capacity of the machines must be so arranged as to meet the requirements when the demand is greatest. Thus gas motors would only in the most rare cases work with a favourable load. It is therefore an important advantage to arrange the operating conditions, so that during the whole of the working period, the gas motors are fully loaded, and the surplus energy used for charging accumulators. In this manner the energy contained in the accumulators serves during the hours of highest demand to assist the generators in supplying the network of mains. The size of the electricity works, or, rather, the horse-power, must be calculated to deal with the day of heaviest load. Reasoning in this manner by means of the diagrammatic curve already mentioned, a line is drawn showing the constantly even output of the machines during the 24 hours for feeding the network and charging the accumulators, whilst the consumption of current indicated above this line is that supplied by the batteries. By the employment of generators only, the horse-power must be such as to meet the greatest demand, but by the use of accumulators it is shown that five eighths of the engine power is saved, whilst at the same time the generators continuously work under the most economically favourable conditions. Let us consider the case where the supply of gas is furnished at 2s. 6d per thousand, this corresponding to the charges made by municipal gasworks to different large consumers. Let us assume two generating stations, each being equipped with three gas-engines of 120 h.p. each. Two of these motors, giving together 240 h.p., will feed a continuous-current three-wire system, whilst the third motor serves as reserve. Each station is able to supply 7,570 16-c.p. (50-watt) lamps simultaneously alight, or both stations 15,140 lamps. If of the number of lamps installed 66⅔ per cent. are calculated as being energised at the same time, this gives 22,710 incandescent lamps connected to the mains, or their equivalent in arc lamps. The radius of the area of supply is 830 yards, or if the two stations are 1,010 yards distant from one another, the combined supply district amounts to 2,780 yards. A pressure of 110 volts at the lamps is provided for with a loss in each outer conductor of 10 volts. There will therefore be required in each of the two stations three gas-engines, each of 120 h.p. (one as reserve), three shunt dynamos (one as reserve) of 110 volts and 697 amperes, capable of working at 120 volts and giving 662 amperes, and yielding at 145 volts 548 amperes; and one battery of 4,628 ampere-hours capacity, the charging current being 662 amperes, and the discharging current 1,060 amperes. The author then enters into the general method of working stations according to this method, and then comes to consider the commercial aspect of the question for two stations, each of 240 h.p. (with 120 h.p. each as reserve), and each capable of energising 7,570 16 c.p. lamps simultaneously. The cost of site, buildings, gas-engines, dynamos, accumulators, mains, etc., works out at £74,000; the annual receipts at ½d. per 16 c.p. lamp per hour, with 15,140 simultaneously burning lamps having an annual number of hours of burning of 750 each, comes to £21,574, and the annual expenditure, after providing for depreciation, totals £9,138. This shows a profit of £12,436, or a return of over 16 per cent. on the initial expenditure. Mr. Uppenborn, in conclusion, states that this system is eminently suitable for towns where the gasworks are the property of the municipal or other local authority.

KILLINGWORTH HEDGES.

Mr. Killingworth Hedges, M. I. C. E., M.I.E.E., was born at Streatham, Surrey, and educated at Brighton until the age of 16, when he was articled to Mr. James Easton, C.E., for five years, during which period he served his time in the shops of the firm of Easton and Amos. Subsequently, after passing the examination of the Royal Engineers Military Board at Devonport, he received a commission in the Royal Monmouthshire Engineer Militia, which he held for three years. His first connection with electricity was in 1878, when he was sent to Paris to report on the then recently-invented Jablochkoff candle. In 1879 he was employed to report to the Mersey Dockyard as to the suitability of the electric light for the Liverpool Docks, and afterwards carried out the present installation. He exhibited switches and arc lamps at the Paris Electrical Exhibition, and obtained a bronze medal; also at the Crystal Palace, where a silver medal was awarded him. He invented the fusible cut-out of metallic foil, which was perfected and used throughout the Vienna Electrical Exhibition, and for which a special certificate from the Scientific Commission was granted. He published a pamphlet entitled "Useful Information on Practical Electrical Lighting," in 1879; and a book with the same title in 1881. He is the author of "The Supply of Electricity by Local Authorities," also "Precautions on Introducing the Electric Light;" of a paper entitled the "Fire Risks of Electric Lighting," read before the Royal Institute of British Architects in 1884; and was awarded a Telford Premium by the Institution of Civil Engineers for his paper on "Central-Station Lighting," published in vol. lxxxviii. of the *Minutes*, 1887, a book entitled "Continental Electric Light Stations" being published not long after. More recently he gave his attention to the question of doing away with oil in bearings, and has invented a special form of carbon material, termed "carboid," which permits of the bearing being heated to a considerable temperature without materially increasing the friction, and has been successfully adopted.

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.Sc.

XV.

(*Continued from page 441.*)

RESISTANCE, *continued.*

Verniers.—As verniers, such as the one just alluded to, are now applied to many instruments where great accuracy of reading is desired, a short account of the methods of constructing and using these extremely useful aids to exact reading is introduced here.

The vernier, so called after its introducer, is a device for assisting the accurate reading of equally-divided scales. Suppose that it is desired to read off a given linear or circular scale to, say, tenths of the smallest division. The pointer or arm which slides along the edge of the scale is made broad enough to have engraved upon it a little subsidiary scale, known as the vernier, whose total length is equal to either nine or eleven of the scale divisions on the large scale, and which is itself divided into ten equal parts. In practice, it is found much more convenient for reading purposes to make the length of the vernier equal to nine scale divisions rather than eleven, whence it is sometimes termed a *nonius*. In all of the three examples of verniers illustrated in Figs. 37 to 39, the length of the vernier has been made equal to nine scale divisions.

The zero-point of the vernier is itself actually the pointer for reading the scale, the other ten lines which constitute the vernier scale being merely for accurately determining the position of this zero-point. Thus, suppose that the vernier zero, which is usually distinguished by an arrow-head or by being made diamond-shaped as in Figs. 37 to 39, is exactly opposite any one of the lines on the main scale, say 822, as shown in Fig. 37. Then the reading of the pointer is exactly 822, or 822·0. But as a vernier division is just equal to one-tenth of nine scale divisions—that is, nine-tenths of a scale division—the next line on the vernier is just one tenth of a scale division behind the next line on the scale.

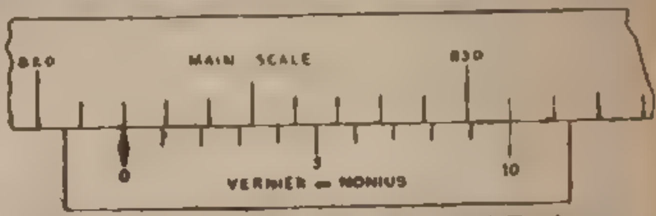

FIG. 37.—Equally Divided Linear Scale, with Vernier.

Similarly, the second line from the zero on the vernier is two tenths behind the next line on the scale, the third line three-tenths, and so on, the ninth line being nine-tenths behind, and the tenth ten-tenths, so that this last just coincides with the ninth scale line past the one opposite the vernier zero, as will be observed in Fig 37.

From this it will be evident that if the first line of the vernier past the zero coincides with a scale line, the reading will be just one-tenth of a scale division more than if the vernier zero had been the coincident line. When the second vernier line coincides, the reading is two-tenths more, when the third, three-tenths, and so on; therefore, to state it generally, when the *n*th line of the vernier coincides with a scale line, the pointer or zero line of the vernier is just *n*-tenths of a scale division beyond the scale mark which it has last passed.

In this way is obtained a very simple and extremely accurate method of reading a scale. First note which of the scale lines the vernier zero has just passed, then observe which of the vernier lines has a scale line most nearly opposite it. The reading of the vernier in this way, counting from the zero, will give the value of the scale reading to tenths of a scale division, with great precision, even although the scale divisions are small. In certain instruments where the scale divisions are very small, microscopes are attached to the scales to facilitate the reading of the verniers.

FIG. 38. - Equally Divided Circular Scale, with Radial Vernier.

FIG. 39. -Equally Divided Cylindrical Scale, with Vernier.

The application of the vernier to various kinds of equally-divided scales is illustrated in Figs. 37 to 39. Fig. 37 shows the application to an ordinary linear scale, the reading of which in the position of the vernier shown is 822·0, as has been already explained.

Fig. 38 shows a portion of an equally divided circular scale, with a vernier reading to tenths of a scale division engraved on the end of a radial arm pivoted at the centre. The reading of this in the position shown is 31·98, as the last scale line passed by the vernier zero is 31·9, and the eighth vernier line is the one which is just opposite to a scale line. Angular surveying instruments, such as theodo-

lites and the like, are usually furnished with scales of this kind, but subdivided rather differently. In an ordinary transit instrument reading to minutes, the main scale or circle is generally divided into half-degrees, and the vernier consists of an arc whose length is equal to 29 of these, divided into 30 equal parts. In theodolites of greater precision, the main circles are made larger and divided into third parts of a degree, and the verniers have a length equal to 59 of these, divided into 60 equal parts, so that they read to thirds of a minute or 20 seconds. In some of the larger astronomical telescopes, where extreme accuracy is of paramount importance, and a very slight error in reading an angle may utterly vitiate an astronomer's calculations, the main circles are made very large and the verniers read to single seconds. In electrical measurements, however, angles are never read to a precision at all approaching this, measurements which depend upon magnitudes of angles for their readings being as a rule only approximate.

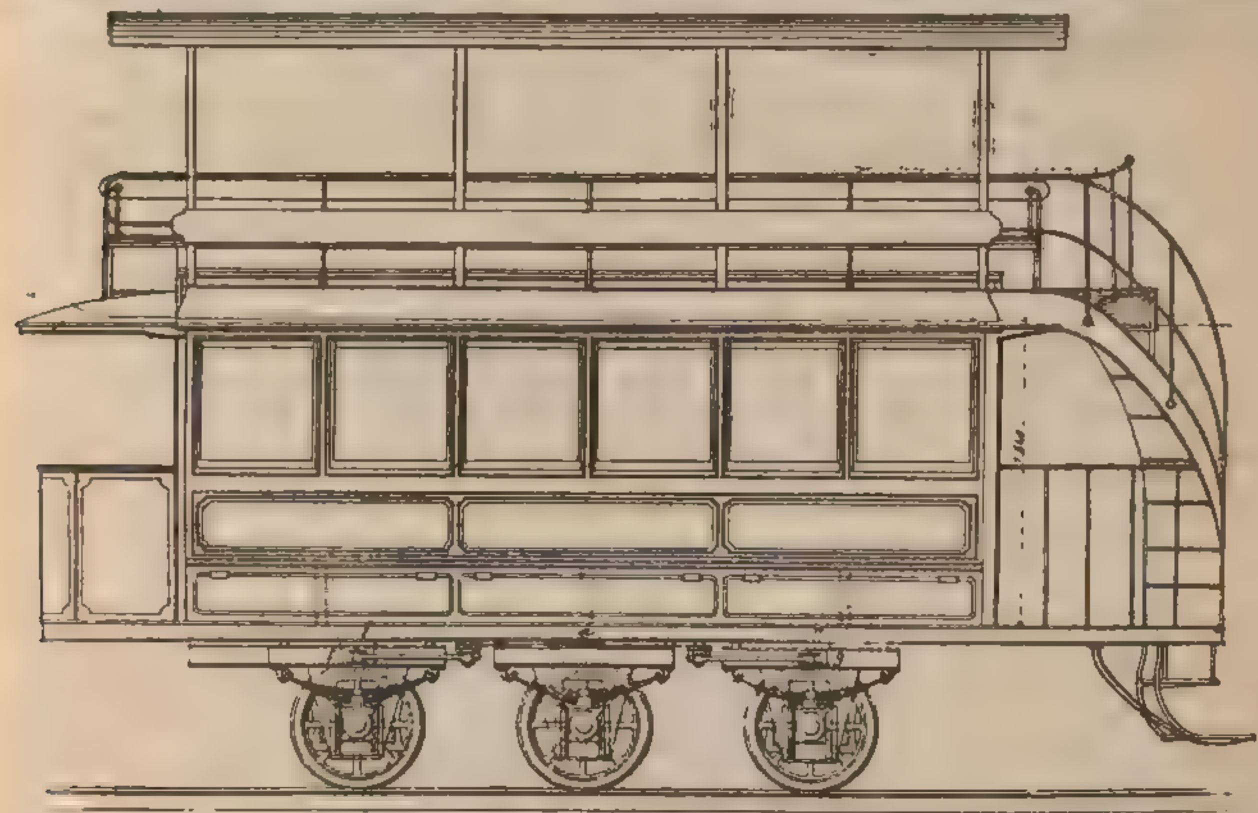

FIG. 1.—General View (in Side Elevation).

In Fig. 39 is shown a portion of a cylindrical surface with an equally-divided scale engraved upon it, and provided with a vernier on a similar cylindrical surface, reading to tenths of a scale division. Most planimeters are read by means of a scale and vernier of this description, the vernier being fixed rigidly to the instrument while the scale is on a roller running on the paper; and as has been already mentioned, Sir William Siemens used this arrangement in some of the later forms of his differential resistance measuring instrument, instead of the flat linear scale and vernier with which the instrument illustrated in Fig. 36 is provided. In the example shown in Fig. 39 it will be seen that the vernier zero lies somewhere between 15·8 and 15·9 on the main scale, and that the fifth vernier line coincides with a scale line. The reading of the scale in the position shown is, therefore, 15·85.

When the total length of a vernier reading to tenths of a scale division is made equal to eleven instead of nine scale divisions, then each vernier division is just equal to eleven-tenths of a scale division—that is, one-tenth more instead of one-tenth less, as in all the examples shown. In this case the vernier has to be read in the opposite direction to the main scale, and errors in reading are apt to arise. Thus suppose the main scale reads from left to right, then the zero mark of the vernier, instead of being at the left, is at the right side of the vernier scale, which has to be read in the opposite direction to the main scale—that is, from right to left.

(To be continued.)

BATTERY CARS IN PARIS.

The electrical engineer learns by experience his constant need of a *nil admirari* state of mind, and hence he considers more or less carefully all the new electrical schemes and projects brought forward, in case there may be a grain or two of wheat amongst a heap of chaff.

Practically it would appear axiomatic that inasmuch as accumulator working has not as yet proved at all successful on tramways where the conditions of employment are fairly favourable, such a method is hardly worth putting into further practice until the ruling conditions of lines or of accumulators are changed.

However, there are circumstances under which even the heavy load of accumulators and motor gear may not prove too great a disadvantage for operating ordinary tramcars; and the Compagnie Générale des Omnibus, of Paris, has for some time been experimenting in this direction to see what practical results can be achieved with a fair amount of success. This company has throughout employed accumulators of the Laurent-Cély type as manufactured by the Société pour le Travail Electrique des Metaux.

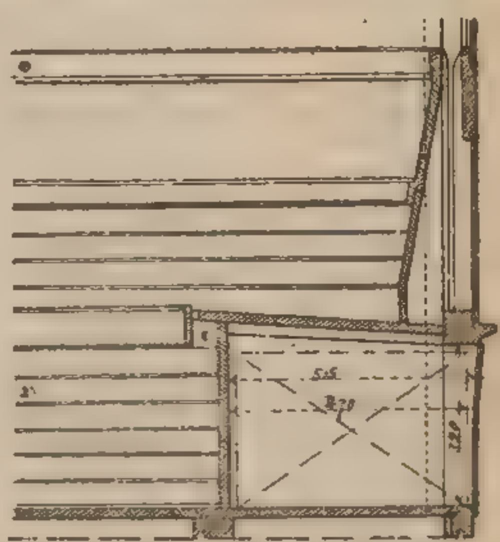

FIG. 2.—Cross-Section through Car-Seat, showing Accumulator Space.

In their first experiments a system of double-reduction gear was employed to connect the motor and car axles, but being desirous of having as little complication of parts as possible, whilst also lessening the noise and wear, the company accepted an offer from the firm of Bréguet to build motors of slow speed suitable for mounting direct upon the tramcar axles. The weight of each gearless motor thus constructed was about three tons, or nearly double that of the high-speed machines previously used. Their input was 10 kilowatts, or 100 amperes at 100 volts. The field-magnet system was suspended from the framework of the vehicle by means of powerful springs, whilst *the armature was mounted upon* a brass sleeve with bearings on the tramcar axle. A flexible connection between the two was provided by means of a disc or ring with four notches, into which were slid four arms projecting from the axle.

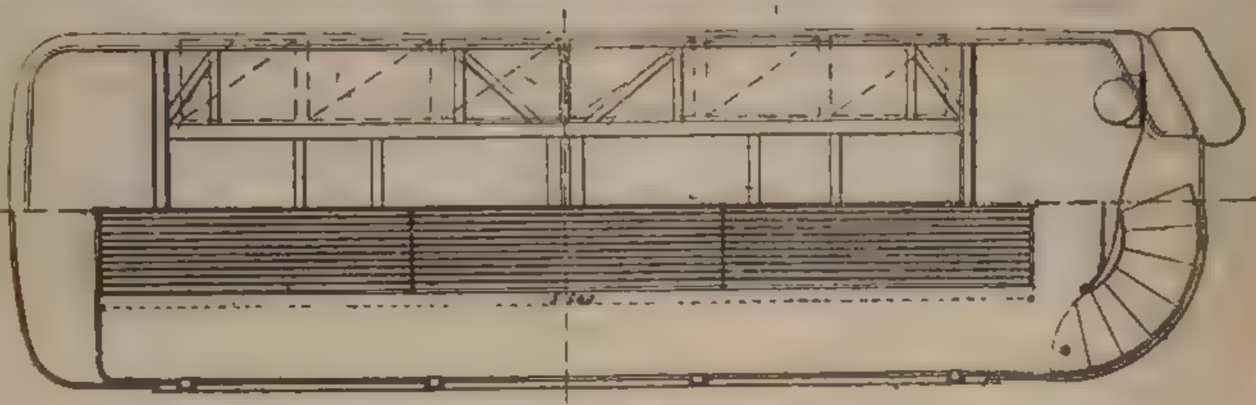

FIG. 2.—Half Plans of Car Floor and Frame.

These gearless motors proved in practice to be even less of a success than the double-reduction arrangement, and the *sors tertia* of a single-reduction gear was then decided upon. This, the latest and, it is expected, the most suitable type, is illustrated in the annexed engravings, reproduced from the *Revue Industrielle*. The arrangement of accumulators is very much the same as in the previous experiments, the Laurent-Cély batteries being placed in three compartments under each seat lengthways of the

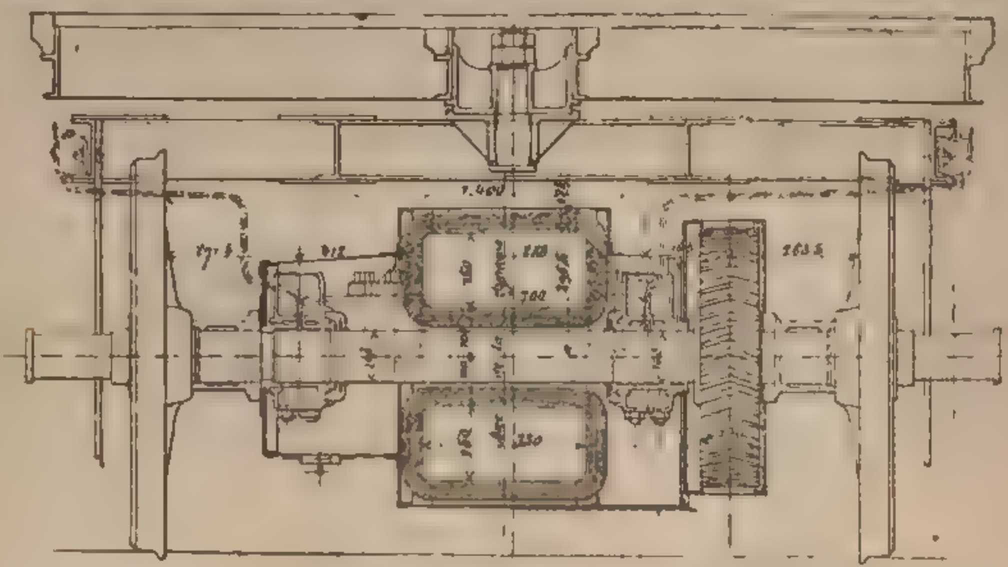

FIG. 4.—Vertical Section Along Line C D (Fig. 5).

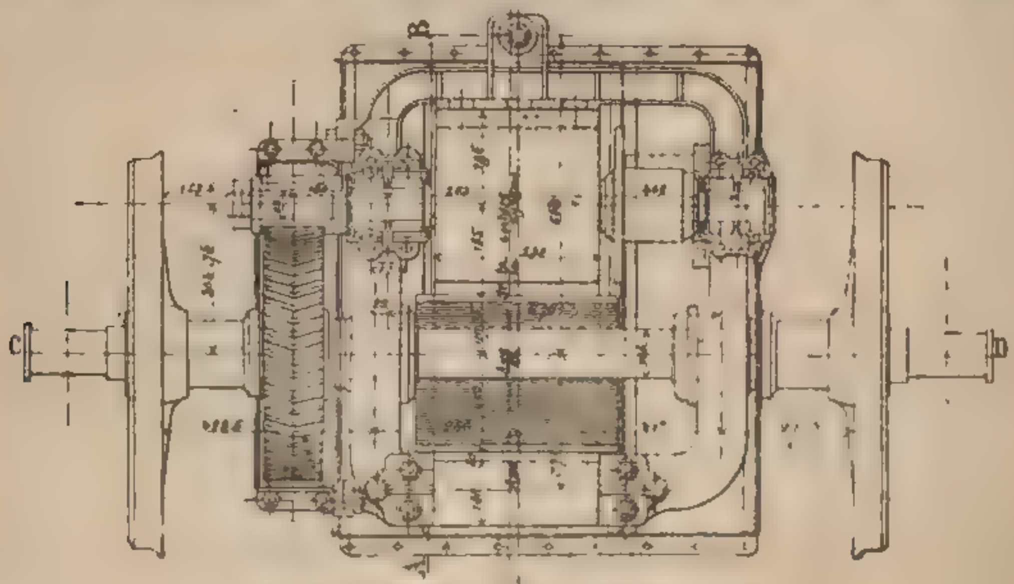

FIG. 5.—Plan and Horizontal Section Along Line E F G H (Fig. 3).

vehicle. Each of these compartments contains two sets of nine cells joined in series, and built up of 11 plates each, five positive and six negative, weighing in all about 400lb. per set. There are, consequently, 108 cells in all, and a total weight—including boxes and other accessories—of some $3\frac{1}{2}$ tons of accumulators. The accumulator spaces and compartments are shown in Figs. 1, 2, 3, giving side elevation, plan, and end elevation respectively.

The reduction gear employed gives a speed ratio between the motor and tramcar axles of, roughly speaking, 5 to 1; a double helical arrangement of tooth is adopted, and every

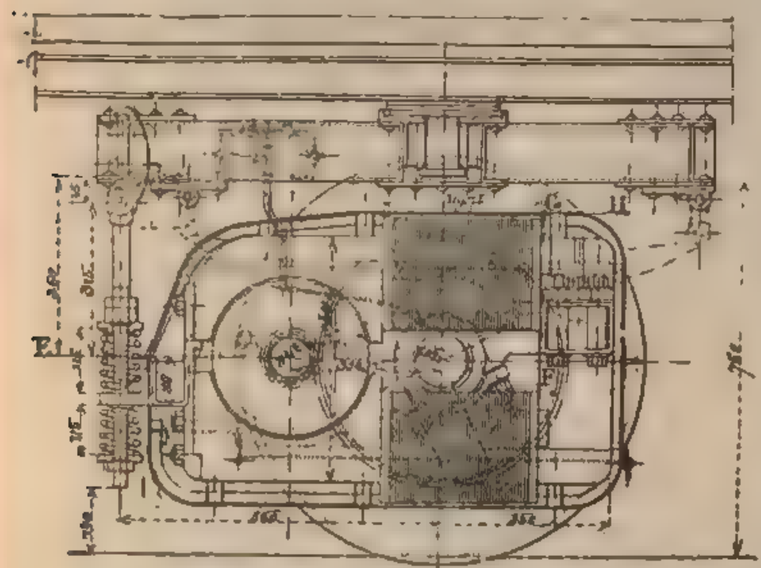

Fig. 6.—Vertical Section Along Line A B (Fig. 5

care taken to ensure accurate and easy running. Apart from any economy in working, there is a considerable saving

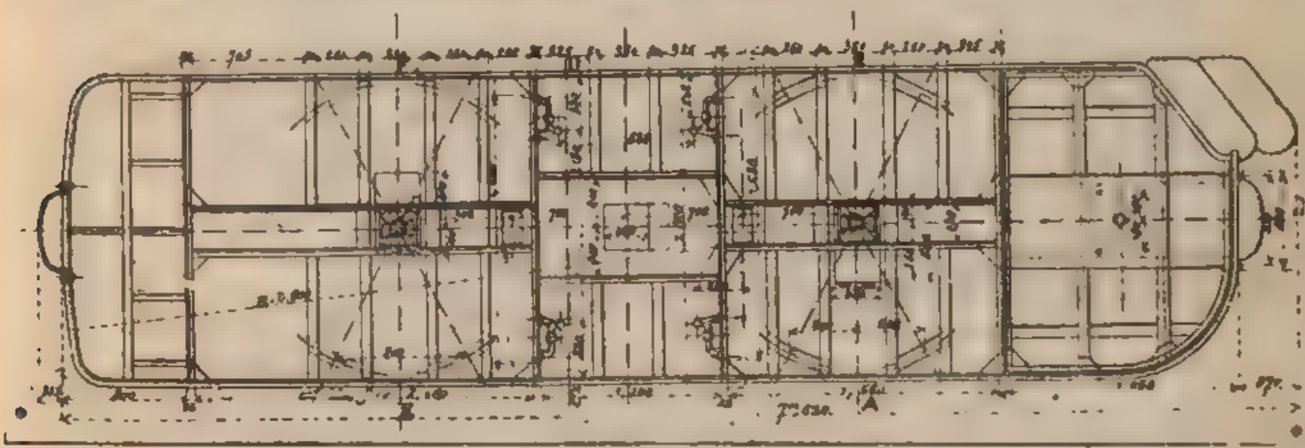

Fig. 10.—Plan of Car-Frame.

effected in weight, the total weight of motor and gear being only about $1\frac{1}{2}$ tons, as compared with double that amount

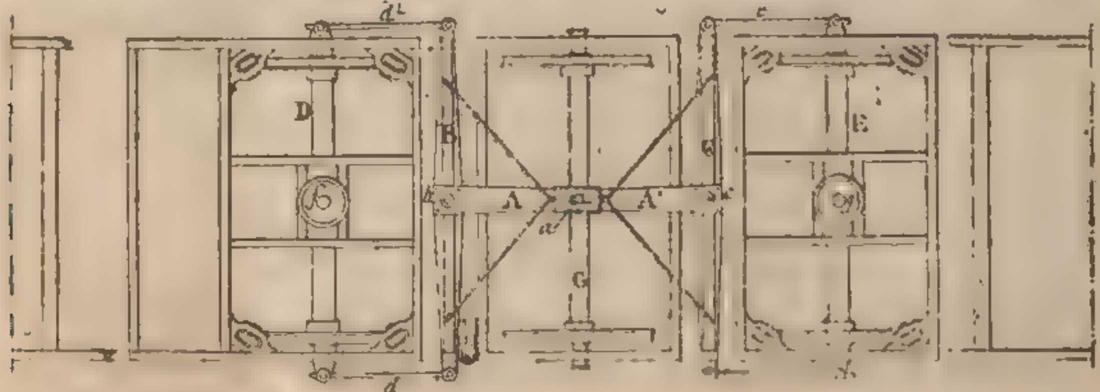

Fig. 11.—Plan of Truck Frames, showing the Radial End Trucks and Guide-Rods.

for the gearless motors. The use of steel for the pole-pieces has so far given working results much better than were expected, and of course implies a saving in weight. In

Figs. 4, 5, 6, and 7 are shown views of the motors and gear: two shunt-wound motors are fitted on each car.

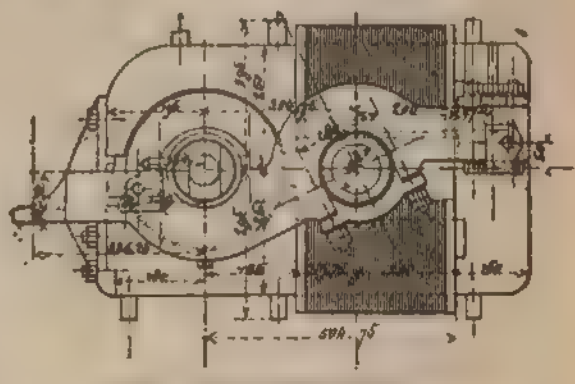

Fig. 7.—Side Elevation of Motor.

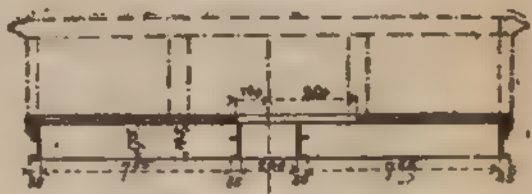

Fig. 8.—Vertical Cross-Section Along Line E F (Fig. 10).

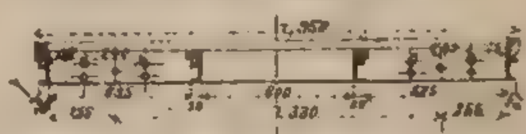

Fig. 9.—Vertical Cross-Section along Line, C D (Fig. 10).

The energy supplied to the motors in accordance with the requirements of the work to be done is in this instance regulated by varying the motor fields after the usual fashion; not, however, by cutting in or out different sections of the field windings, but by introducing a variable outside resistance into the shunt and thereby varying the current which passes through it.

The regulator handle, which serves to effect these variations, and thereby stops or checks the vehicle more or less rapidly, also acts as a reversing lever; it operates two contact rings, one of which gives the various movements in forward or backward gear, putting on the brakes and closing or opening the magnet circuit, whilst the other regulates, according to requirements of power from time to time, the strength of the magnetic field.

Precautions are taken to avoid sparking, when the main circuit is made or broken, by a series of intermediate contacts with resistances, so that the main current is only cut off from one contact to another when the respective by-pass is open; and the same thing is done with the shunt current. A rush of current through the field, before magnetisation, is prevented by employing for closing the shunt circuit an additional contact operated by the main regulator handle.

Perhaps the most interesting feature of this new type of car is the flexible system of trucks or motor axles adopted.

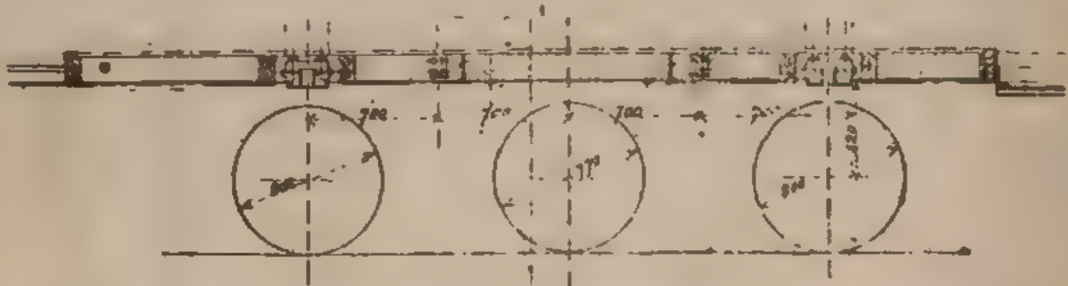

FIG. 12.—Vertical Section (length-ways) of Car-Frame.

The axles on each car are three in number; those at each end serve to carry the motor, and with the truck frames which they support, have a radial motion as well as a slight play backwards and forwards in the framing, so as to allow of easy running round curves. A system of arms, swivelling on the centre axle, give the requisite swinging movement round a massive pin, *a*. Gudgeon pins at *b* and *c* are attached to the car frame, and slide in small slots in the swivelling truck frame, thereby serving to limit the motion of the latter. This system of flexible yet strong connection between the car axles is due to M. Garnier, and the details of it are clearly seen in Figs. 8, 9, and 10. Figs. 11 and 12 illustrate cross-sections of the car framing. Curves of a radius as low as 40ft. are successfully operated by means of these trucks.

HEAT GENERATED IN ELECTROLYTIC CELLS.*

BY G. E. ALLAN, B.SC.

This paper is a record of experiments begun in March, 1892, by Mr. F. W. Dunn, B.A., and myself, to find what heat was given off in certain electrolytic cells—viz., those in which the electrodes were of zinc and platinum. Our first intention was to have cells of Pt. Pt., Zn. Zn., and Pt. Zn. in battery acid of the proportion of 1 to 8, the electrolysis to be performed by the current from the Pt.-Zn. cell, but the current given by two cells of this kind was so small that the rise of temperature was inappreciable. I may say that we afterwards found a current of one-tenth ampere did not always give heat to balance the cooling of the air. To remedy this we took sulphuric acid of the best conductivity — Matthiessen giving that sulphuric acid diluted with water to a specific gravity of 1·215 at temperature 12·3 C., or almost exactly 30 per cent. acid, has the least specific resistance of any combination of sulphuric acid and water. But even this did not give a workable result, so we had recourse to outside help, and after this used a current from a battery of accumulators. Our preliminary experiments showed us that the cells stand in the following order as regards rise in temperature: Zn. Pt. with the lowest rise, then Zn. Zn., Pt. Pt., and Pt. Zn.; the first-mentioned metal in each case being the anode.

Some of the particulars which we took during each *experiment* were: the quantity of liquid in each cell

PRELIMINARY EXPERIMENTS.

Strength of current in amperes.	Rise in temperature, C.				Time current passed.
	Z. P.	Z. Z.	P. P	P. Z	H. M
·121	—	·5	·37	—	1 20
·117	—	·45	·41	—	0 50
1·36	—	·75	·65	—	0 50
2·05	—	3·1	3·8	—	1 0
2·05	—	2·7	3·4	—	0 50
2·04	—	4·0	—	4·4	0 50
2·10	2·4	3·2	—	—	1 0
1·85	2·7	2·8	3·0	5·5	1 0
1·96	2·8	2·9	4·9	5·3	1 0
1·98	2·4	2·6	4·1	4·8	1 0
1·93	2·1	2·9	3·7	4·3	1 0

(generally about 500 c. cm.); the temperature of the air, at intervals of time, by cells of water placed between the others; the difference of potential between the electrodes of each cell; and the weight of zinc consumed at electrodes of that metal, besides recording the temperature of each cell and the strength of the current at fixed intervals.

The specific heat of the acid was found to be ·82; and as regards the consumption of zinc, Woodward gives the following figures on the heat which is due to the chemical action of the acid on the zinc:

Heat from 1 gm. Zn on changing to ZnO, 1,314 g.w.u.
Heat from this ZnO on dissolving in H_2SO_4, 360 g.w.u.
Heat absorbed by dissociating O from water, 1,061 g.w.u.

Total per gm. zinc, 613 g.w.u. (g.w.u. stands for gram-water-unit). So that in calculation of the heat due to chemical consumption of zinc we had only to multiply the weight of zinc used by 613. Joule gives that 100 grains ZnO on dissolving in H_2SO_4 are able to raise 1lb. of water 6·88deg. F.

One great cause of trouble to us at first was the shaking of the platinum plates when the liquid was stirred. Corrugation of the plates was tried. This was no use. At last the Pt. plates were stiffened by welding them on to rectangular frames of glass tube bent into the shape of the plates. In this state they were firmer than the zinc plates. The platinums gave us a little trouble after this by sometimes coming loose from their frames. Dr. Bottomley suggested that this might be due to the occulsion of hydrogen. It is very probable that this was the case—Graham having shown that platinum occludes hydrogen to some extent when it is made the negative electrode of a voltaic couple, and expands with the absorption.

CONTINUATION OF EXPERIMENTS WITH FIRM PLATINUM PLATES.

Current in amperes.	Rise in temperature.				Time current passed.
	Z. P.	Z. Z.	P. P.	P. Z.	H. M.
·47	·6	·7	·9	1·5	1 22
·44	[illegible]	·6	[illegible]	·9	0 55
—	·41	—	—	—	—
·498	·31	·56	·56	—	0 33
·44	·47	·54	·64	·94	0 56
1·46	1·22	1·37	1·87	2·37	0 46
1·1	·7	·87	1·07	1·47	0 35
1·01	·77	·73	1·33	1·43	0 40
1·0	·93	·7	1·3	1·65	0 47
0·1	0	·1	0	[illegible]	0 38

*Paper read before the Physical Society of Glasgow University.

In these experiments the current was not regulated to a particular value, but its strength was read off at intervals from the ampere balance which we used for that purpose, and during the experiment the current gradually decreased, electrolytic resistance increasing with rise of temperature. From the number of observations made during the experiment there was no time left to work a rheostat, even if we had wished to keep the current constant. But this was done in the later experiments. In November the work was continued, in order to find which plate in each cell became the hotter.

Three cells were used—those of Z P., Z Z., and Pt.Z. The two plates in each vessel were separated by a blotting-paper partition, and there was a thermometer at each plate. There were no stirrers used, the temperature being taken by placing the thermometer at the centre of the plate before reading it.

RESULTS.

Current.	Rise in temperature.						Time of current.
	Z.	P.	Z.	Z.	P.	Z.	H. M.
1·0	1·73	1·83	1·68	1·58	2·88	2·58	1 0
1·0	1·02	1·17	1·07	1·22	2·42	2·27	1 0
0·5	0·41	0·43	—	—	0·76	0·66	0 30
0·5	0·94	1·09	·74	·94	1·40	1·40	1 0
0·5	0·47	0·62	·72	·67	1·17	1·07	1 0
0·25	0·06	0·11	·31	[illegible]	0·71	0·61	1 0
0·25	0·05	[illegible]	·0	·15	0·3	0·1	1 0
0·1	[illegible]	0·26	·06	·11	0·66	[illegible]	1 0

From the last set of experiments it will be seen that in the Z.-P. and P.-Z. cells the platinum was always hotter than the zinc, with one exception (February 10)—when they were equal in the P.-Z. cell. In the Z. Z. cell, twice the anode was the warmer and the cathode five times. Several experiments were made with a current of ·1 ampere, but the season of the year (February) was not suitable for observing the heating effect of such small currents, there being sometimes a fall of temperature during the experiment instead of a rise.

After this a different method was tried, but as it involved the use of tube in which a great rise of temperature took place, the results obtained from it cannot be so reliable. Taking two zinc plates, each in a beaker by itself, the two vessels were connected by a syphon tube 18in. long and ½in. bore with 3in. legs. The capacity of the tube was 70 c. cs., and there were 500 c. cs. of acid in each cell. The following results were obtained with this method:

Current.	Cell.	Rise in temperature.		Time.
		Anode.	Kathode.	H. M.
1·0	Z Z.	1·07	2·07	0 30
1·0	Z.P.	·83	1·53	0 30
1·0	P.P.	1·32	2·02	0 30
1·0	P.Z.	1·58	1·68	0 30
1·0	P.Z.	1·0	1·2	0 25

Here the cathode is always the hotter, no matter what cell, although in the last two the rise is much nearer equality than in any of the others. At the end of half an hour the connecting tube became so hot that it could hardly be held in the fingers. It must have been about 70deg. C. Again this method was changed for another. The syphon tube was inverted, placed on a stand, and the electrodes were put into the legs. Zinc sheet and platinum foil were shaped into small cylinders to fit the legs of the U-tube and the thermometers were put inside the cylinders.

Current ampere.	Cell.	Rise in temperature after two minutes.		Rise in temperature after 10 minutes.	
		Anode.	Cathode.	Anode.	Cathode.
·5	Z. Z.	2·45	3·1	16·7	11·9
·5	Z. Z.	2·3	2·45	14·8	11·75
·5	Z. P.	2·65	3·3	20·2	15·9
·5	P. Z.	4·45	3·7	19·45	13·35
·48	Z. P.	2·1	2·2	15·9	10·2

When observing, the temperature had to be read every minute, the increase in temperature being very rapid. These experiments showed that the final temperature of the anode was always greater than that of the cathode, although when zinc was the cathode it showed a rapid rise at the beginning, and this might explain why in former experiments the results were not uniform for the Z.-Z. cell.

These investigations are still in an unfinished state, and I am sorry they are not in a more advanced condition before being placed before the society.

AN EXTENSIBLE ELECTROLIER.

We illustrate an electrolier by an American designer, Mr. A. Rivenburgh. It consists of a tube containing strips of conductive metal connected with the wires of the house circuit, a tube of insulated material sliding therein, and having contact springs which connect to conductors leading to the lamps through the sliding tube. Fig. 1 shows the electrolier complete, Fig. 2 being a transverse section, and Fig. 3 the top portion of the sliding tube. The hole in the

FIGS. 1, 2, AND 3.

main tube is preferably rectangular, and the metallic strips in its opposite sides are flat. The springs connecting the strips, on the upper end of the sliding tube, are insulated from each other and connected with the wires extending down the inner tube and leading to the lamps. Additional strips of insulation are inserted in the walls of the main tube to prevent the springing of the metallic strips, and, to hold the sliding tube in any desired position, a spring and a set screw, which may be made to bear upon it, are arranged in the side of the main tube.

STREET-LIGHT TESTING.

Athens is a thriving city in the State of Georgia (United States) and deserves notice, if only because the arc lights which illuminate its streets are provided and maintained by the Athens Gaslight Company. Some at least of the gas interests are wide awake to their most prudent course. The city authorities of Athens, however, grew suspicious of the illuminating intensity of the arc lamps, and authorised a series of tests to determine whether or not the company was complying with their contract as to candle-power. The tests conducted so far by the city engineer have been made with a Bunsen photometer. A sperm candle consuming 120 grains per hour was used as the standard. The tests were conducted as follows: The light to be tested was lowered to within about 5ft. of the street surface, the photometer placed with the opening in one end in the direction of the electric light, and the candle used as a standard was placed 1ft. from the greased diaphragm and opposite the opening in the other end. With the photometer in this position the instrument was moved back and forth until the image appeared the same in each mirror. The square of the distance of the lamp from the centre of the instrument was taken as the candle-power of the light tested.

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JOHN TYNDALL.

The world is poorer in intellect to-day than it was when last we wrote. A leader has passed away; aye, a greater leader than most are willing to admit. Few among the sons of men are left in whom truth and justice, honour and loyalty, are above monetary considerations. True to himself, true to his friends, true to his country, a hater of shams, a despiser of sycophants, a detester of opportunism, lived and died John Tyndall. Adversity had no terrors, prosperity brought no false pride, energetic in the pursuit of scientific truth, bold and blunt in expressing his convictions, he feared none, but walked through life earnestly endeavouring so to conduct his affairs as to leave the world better than he found it. He suffered because of his honesty, for he had the courage of his opinions—and in a worldly sense this trait in a man's character does not usually increase his prosperity. The world would not be worth living in were it not leavened by such as he. Our admiration for the late professor has hardly any bounds, for to us he was a many-sided hero. What was his endowment? Not wealth, not private tutors and college lectures, not time to study; nothing more than great natural ability, a keen desire to know, and a determination to excel. With these the unknown lad took a position among the great ones of the earth. A stupendous task fully achieved. Perhaps our greatest admiration, however, is for the teacher. Three classes of men take almost equal rank in this world, and first of these is the teacher, next to whom we would place the scientific truth-seeker, and then the honest politician. The teaching ranks, again, would take two classes—those practising religious teaching and those occupied with more mundane affairs, though to separate the one from the other in the real teacher is somewhat difficult. Who was it that described a genius as one capable of taking infinite pains? The real teacher is a genius. Tyndall was a real teacher, and he had an almost superhuman power of taking pains. Examine his treatises, "Heat a Mode of Motion," "Sound," "Forms of Water," and find, if you can, a redundant word or an undigested sentence. Commencing with the simplest and most understandable experimental facts, he gradually, by adding simple to simple, builds up a perfect explanation of the most complex phenomena. The matter, method, and manner of his lectures at the Royal Institution or elsewhere, were not one jot inferior to his written books. Clear and concise, every word of use, illustrated by diagrams and experiments, fitting so accurately and explaining so beautifully, that the meanest intellect amongst the audience could not fail to grasp the argument and agree with the conclusion. We have by his death lost a great teacher, but his influence will live. Some of our young readers may not understand the value of Tyndall's work. They will not recognise him as a great electrician, perhaps not as a great physicist as reputations now go, but to some of us who lived and worked a few decades ago his influence is known to be that of an era maker. Darwin has long gone to his rest, Tyndall now

follows, leaving amongst us Huxley to represent a triumvirate whose names will linger in scientific history as long as history itself endures. Have they not taught the world to be slow in coming to conclusions, to investigate carefully, systematically, and thoroughly; that rash assumptions are often worthless and unprofitable; and, above all, that the aim of the scientific man is to establish the truth? A few brief words as to Tyndall's life and this attempt to express the regret we feel at the loss the world has sustained must be concluded. Tyndall was descended from a worthy English stock, one of his ancestors being W. Tyndale, a translator of the Bible, the family belonging to Gloucestershire. The late Prof. Tyndall was born in 1820 in Ireland, in the village of Leighlin Bridge, near Carlow, his father being but an humble tradesman. The youth was kept at school till his nineteenth year, when he entered the Ordnance Survey service, afterwards going to a Manchester firm. In 1847 he became a master at Queenswood College, Hants, and next year went with Frankland to Marburg to study chemistry. In 1850 he made Faraday's acquaintance, and from that time his life's work, till 1887, was connected with the laboratory of the Royal Institution. In the latter year he retired to live at Hind-head, where he wanted quiet to finish certain work which he had set his mind to accomplish. Unfortunately, time has not been given him to complete that work. Of his scientific investigation his books must speak. Of himself the poet speaks:

> Thou art gone,
> And he who would assail thee in thy grave,
> Oh, let him pause! For who among us all,
> Tried as thou wer't . . .
> Ah, who among us all
> Could say he had not erred as much or more?

TOWING BY ELECTRICITY.

The adaptation of electrical energy in any new direction deserves attention, and when we consider the decadence of canal traffic upon our English canals anything which promises to assist in resuscitating their activity will be welcomed. In America and in France experimental trials have been made in regard to electric towing. France claims precedence in this new departure, both as regards point of time and extent of experiment. Here upon the Bourgogne Canal, nearly four miles long, with more than half the length in tunnel, for the past two months electric, has successfully replaced horse towage. There are two stations wherein Gramme machines are driven by water power, one at each end of the canal. The Gramme machines are put in series, and parallel line wires arranged so that the motor placed between takes off from one wire, making the return through the other. The motor drives by two sets of gearing—one for light and the other for heavy load. With a light load, the distance was run in about 45 minutes, using a current of about 12 amperes; with a heavy load of 17 boats carrying 1,500 tons it took two hours, using a current of 20 amperes. The normal speed of the motor is 1,000 revolutions per minute. Accumulators are used as regulators. The American experiment is of a different character, and has been carried out on the Erie Canal. The Legislature voted a sum of 10,000dol. for investigating the merits of electricity as a motive power on canals. An ordinary steam canal boat was taken, the engine and boiler replaced by two 25-h.p. Westinghouse street-railway motors of standard type, connected direct to the propeller shaft. The line wires were erected much as on street railways, and two trolleys used to connect with line and return. These overhead wires were of No. 0 copper trolley wire strung 5ft. apart. A current at 500 volts pressure was promised, but in the end a pressure only of from 200 to 250 volts was obtained. The results in this case were very successful. We do not mean to indicate that the problem of electric traction upon canals has been completely solved, nor have we any information as to cost. That electrical towage is possible is certain, whether it can be made commercially successful is another question. In many cases, as at the Bourgogne Canal, the prime motor power may cost nothing, but even then the cost of an installation and maintenance will be considerable. English canals are comparatively little used. Some people contend that this is the result of railway competition and ownership; others assure us that it is the result of the product time and cost. At any rate, those interested in the matter ought to consider how far electricity will help them to a renewal of activity.

CORRESPONDENCE.

THE LATE ANTHONY RECKENZAUN.

SIR,—Will you allow me a space in the columns of your journal, which has amongst its readers so many of my late husband's friends, to thank them for sending me, in such numbers, letters of sympathy and condolence?

Their number is far too great for me to reply to them individually, and I hope you will give me this opportunity of expressing to them my warmest thanks, and the gratification it is to me to know how universally my husband was beloved and respected.—Yours, etc.,

34, Hemberton-road, S.W. E. RECKENZAUN.

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Sir Henry Mance, C.I.E., M Inst.C.E.
Prof. George Forbes, F.R.SS. (L. and E.).

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Prof. J. A. Fleming, M.A., D.Sc., F.R.S.
Walter T. Goolden, M.A.
Gisbert Kapp, M.Inst.C.E.
Prof. A. B. W. Kennedy, F.R.S., M.Inst.C.E.
W. M. Mordey.
Prof. John Perry, D.Sc., F.R.S.
James Swinburne.
*Major A. H. Bagnold, R.E.
*W. B. Esson.
*Robert Kaye Gray.
*Augustus Stroh.

ASSOCIATE MEMBERS OF COUNCIL (*three to be elected*).

*G. K. B. Elphinstone.
*Dr. W. E. Sumpner.
*The Earl Russell.

* Recommended by Council.

POLYPHASE ALTERNATE CURRENTS.

(Continued from page 465.)

Alternate-Current Motors.

The third of the desiderata mentioned in the last article is that of means to transform the electric energy of alternate currents into mechanical energy, and is specially interesting because it offers solutions to the two others.

Since alternate currents were first used there have been constant demands for a practical alternate-current motor The problem has been solved in various ways, which may be passed in review. Alternate-current motors can be divided into three classes:

1. Motors with constant magnetic field.
2. Motors with alternating magnetic field.
3. Motors with rotating magnetic field.

1. Motors with Constant Magnetic Field.

If an alternate current traverse an armature of any kind placed in a constant magnetic field, and if this armature has been first brought to an angular velocity correspondent to the alternate current, the rotation will continue synchronously with that of the alternator which produces the current. But if the mechanical resistance increases too much the synchronism is destroyed and the motor stops.

To render the motor self-exciting, M. Zipernowski has devised the part commutation of the alternating current as a shunt, using the redressed current to produce the magnetic field. Under these conditions synchronism is more easily kept.

These motors have a high efficiency. For certain applications synchronism is not a defect, but an advantage. But the necessity of first bringing the motor to speed causes their rejection for most purposes.

2. Motors with Alternate Magnetic Field.

If an alternate current is passed into a continuous-current motor, the latter begins to turn. But the loss by hysteresis, and especially eddy currents, is enormous. This can be obviated by using laminated magnets for the armature. By suppressing iron altogether we arrive at the electro dynamic motor which is used by Elihu Thomson for his motors.

Mordey has proposed to rectify the current by a commutator placed upon the axle of the motor. At start, the effect is nil, but as the speed increases it becomes more nearly as in a continuous-current motor.

In motors with closed circuits, the armature coils, being subject to the action of an alternating field, are the seat of E.M.F.'s. By closing them upon themselves at a suitable moment, they produce a motor couple which makes the armature rotate. This class of motors has not been employed because of the low efficiency—and small specific power (in the case of the electro-dynamic motor).

3. Motors with Rotating Field.

Motors of this class are based upon Arago's experiment showing how Foucault currents generated in a disc of copper over which magnets rotate will eventually put this disc in motion, until the same or almost the same speed as that of the magnets is attained.

With regard to the production of a rotating field by means other than the rotation of a magnet, it was in 1888 that Ferraris showed that when two alternate currents of the same period, but displaced, traversed two circuits making a certain angle with each other, the resultant of the two fields so produced is a rotating field to the extent of one turn per period. Under certain conditions the field may turn with uniform movement and constant intensity.

If a circuit closed on itself is placed in a rotating field, it is the seat of induced currents which cause it to rotate in the same direction as the field and with the same speed. Further, diphase currents of various kinds can be obtained from a single current, thus:

(*a*) By employing the current itself and a current produced by a transformer whose primary is traversed by the main current (Ferraris).

(*b*) By combining two circuits whose time-constant is very different (Tesla).

(*c*) By employing a second circuit closed on itself and making a certain angle with the circuit traversed by the alternate current. A current is therein developed by induction which creates the second alternating magnetic field necessary to the production of a rotating field (Shallenberger).

(*d*) Lastly, Hutin and Leblanc propose a general method based upon the use of condensers.

Generally it is considered more convenient to produce polyphase currents direct by a special machine. Two currents can be used, conducted by four wires, or by three (with common return)—Ferraris, Tesla; but as it is necessary to have at least three wires, it is better to have three currents displaced one-third period, remembering that at each instant their algebraic sum is nil—that is, at each instant one conductor may serve as common return for two others (Bradley, Dobrowolski, Haselwander, Wenstroem). This is the class of motors we wish particularly to study.

The Rotating Field.

Rotating magnetic fields can be produced by any number of alternate currents suitably displaced. We distinguish diphase, triphase, or polyphase according to whether two, three, or more currents are used.

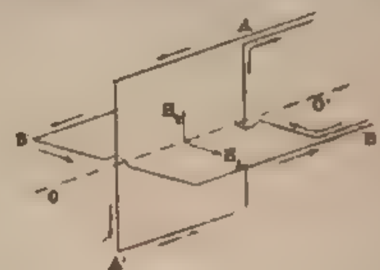


Fig. 8.

Consider two similar coils, A A' and B B' (Fig. 8), making a right angle between them as shown, and traversed by two currents having the direction shown by the arrows. Let these be alternate currents with the same periodicity, T, and same amplitude, A. The current in A A' at any given moment, t, is

$$C_1 = A \sin \frac{2\pi}{T_1} t;$$

or, putting $\omega_1 = \frac{2\pi}{T_1}$ $\qquad C_1 = A \sin \omega_1 t.$

If the current in B B' is a quarter of a period in advance at the given moment, t, its current will be

$$C_2 = A \sin \frac{2\pi}{T_1}\left(t + \frac{T_1}{4}\right) = A \cos \omega_1 t.$$

Supposing the law of current variation to be sinusoidal, which is practically true.

Fig. 9.

If H_o is the intensity of field produced by current, A, traversing one of the coils, then the intensities of fields produced by C_1 C_2 respectively, are

$$H_1 = H_o \sin \omega_1 t,$$
$$H_2 = H_o \cos \omega_1 t,$$

and as these are at right angles to each other the resultant field is

$$H = \sqrt{H_o{}^2 \sin^2 \omega_1 t + H_o{}^2 \cos^2 \omega_1 t},$$

that is to say, H_o.

1. *Diphase Field.*—Let α be the angle made by the resultant field at the moment, t, with the plane A A': we have:

$$\tan \alpha = \frac{H_1}{H_2} = \tan \omega_1 t.$$

It follows from this that the resultant field in the conditions given has a constant intensity and turns with an angular velocity, ω_1—that is, makes one turn per period of the alternate currents. Its direction is *f*, Fig. 9, if we suppose the current, B B_1, in advance of A A_1, and the initial rotation established as in the figure.

Practically, to obtain a more intense field the right-angle arrangement is replaced by a field-magnet system with laminated iron plates, insulated one from the other to avoid eddy currents. For example, the arrangement in Fig. 10 may be adopted. An iron ring carries four windings, AA', BB', united in pairs, as shown. It is easy to see that we shall have a rotating field identical to that just described.

To transmit these two alternate currents, only three conductors need be used. The strength at each instant in the

FIG. 10.

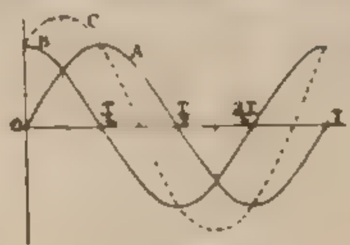


FIG. 11.

return wire undergoes variations, as shown in Curve C, Fig. 11.

Its value is at the moment, t

$$C_1 + C_2 = A\ (\sin \omega_1 t + \cos \omega_1 t).$$

If we simply assume that the specific loss of energy in this conductor never exceeds the maximum value that it attains in one of the other two conductors, the section of return wire will be given by the relation:

$$\frac{C_1{}^2 \max}{s^2} = \frac{(C_1 + C_2)^2 \max}{s'^2},$$

s being the section of one of the two conductors, and s' that of the common return.

The maximum of C_1 is A;

That of $C_1 + C_2$ is $A\sqrt{2}$;

Whence $\qquad s' = s\sqrt{2}.$

It is necessary to remark that often the section adopted for the conductors, s, would be capable of carrying a current of greater intensity than A without danger from heating. More often s will have been determined by the loss of energy allowed on the line. In this case we can adopt for the third wire this same section, s, without increasing the loss in the line, and thus realise a saving of a quarter of the copper.

As a fact, the loss per period with four conductors of section s and resistance r was:

$$W_4 = \frac{4\, r\, T_1 A^2}{2}.$$

In the case of three conductors of identical section the result was the same.

2. *Triphase Field.* —In this case three currents of the same

FIG. 12.

FIG. 12B.

amplitude and period are employed, but displaced one-third period, Figs. 12 and 12B. At a given instant, t, their strengths will be—

$$C_1 = A \sin \omega_1 t;$$

$$C_2 = A \sin \left(\omega_1 t + \frac{2\pi}{3}\right);$$

$$C_3 = A \sin \left(\omega_1 t + \frac{4\pi}{3}\right).$$

Putting $\omega_1 = \frac{2\pi}{T_1}$, the strengths of the three fields at the same instant will be—

$$H_1 = H_o \sin \omega_1 t;$$

$$H_2 = H_o \sin \left(\omega_1 t + \frac{2\pi}{3}\right);$$

$$H_3 = H_o \sin \left(\omega_1 t + \frac{4\pi}{3}\right);$$

calling H_o the strength of the field produced by the current of intensity A circulating in one of the coils.

FIG. 13.

To estimate the strength of resultant field, it may be noted that H_1, H_2, H_3 make angles of 120deg. $\left(\frac{2\pi}{3}\right)$ between themselves. Take two axes: oy following H_1; and xx' perpendicular to oy. Let x_1, x_2, x_3, and X; y_1, y_2, y_3, and Y be components of the magnetic intensity of the fields following these two directions, Fig. 13; we shall have

$$X = \frac{3}{2} H_o \cos \omega_1,$$

and

$$Y = \frac{3}{2} H_o \sin \omega_1 t.$$

The strength of the resultant field is at the moment, t, therefore equal to

$$H = \sqrt{X^2 + Y^2} = \frac{3}{2} H_o.$$

This strength is constant.

The value of its components X and Y show us, moreover, that the field turns with a speed $\omega_1 = \frac{2\pi}{T}$, that is to say, one turn per period of the currents.

It is well to remark here that the algebraic sum of the strengths of the three currents is constantly nil: thus

$$C_1 + C_2 + C_3 = A \left[\sin \omega_1 t + \sin\left(\omega_1 t + \frac{2\pi}{3}\right) + \sin\left(\omega_1 t + \frac{4\pi}{3}\right)\right]$$

$$C_1 + C_2 + C_3 = 0.$$

It follows from this that to transmit these three currents the return wires could be suppressed by joining the three ends of the circuits. At each instant one conductor acts as return to the other two.

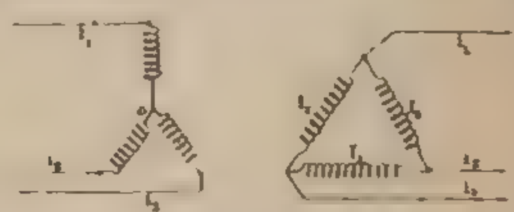


FIG. 14.

The three windings are practically arranged on a laminated inductor, in a similar manner to that indicated for the diphase field. They can be grouped in two ways—in star-shape or as a triangle, Fig. 14. The grouping in star form seems to be the best; indeed, a slight asymmetry in the three coils only causes an insignificant disturbance in the splitting up of the currents. It is not the same with grouping in a triangular form.

(To be continued.)

GOOD "CONTACT" ON ELECTRIC RAILWAYS.

Our American contemporary the *Street Railway Review* tells us once more of the difficulty experienced in getting good electric contact on electric tramways, and illustrates two examples of recent design in such contacts. The first, Fig. 1, is that of H. R. Keithley, and is known as the "Chicago bond," being used in that city. From one piece of copper a bond is rolled with thimble or tube-shaped ends. These ends being inserted in the holes, the edges of the tubes are bent back to temporarily hold the bond in place, and an iron plug is riven in the tube. This plug manifestly expands the soft copper tube so that it makes a moisture-proof contact, and at the same time one of large area.

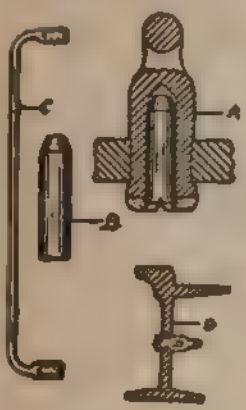
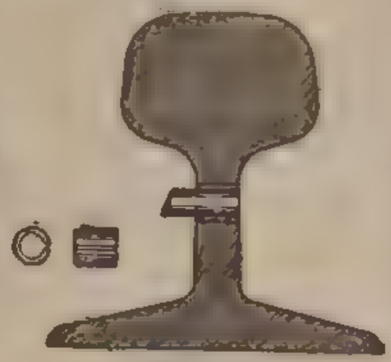


FIG. 1.



BUSHING BOND.

FIG. 2.

The principle of expanding a tube to fit a hole is the same as that used in putting in boiler flues, and if it is possible to expand an iron flue to a watertight fit it is evident that a soft copper tube can be so expanded.

A second system, Fig. 2, also from Chicago, shows another design to solve the difficulty by means of a spring bush. The bushing is a slightly tapered ring with a $\frac{1}{32}$in. split down one side. It is slipped over the end of the contact plug, and driven in a manner like to a channel pin. In driving the slit spring closes, and makes continuous contact over the entire circumference of the contact-piece.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE V.

(Concluded from page 522.)

The Paris System of Distribution of Power by Compressed Air.—The Paris power distribution is at present the largest in Europe, but it developed out of very small beginnings. About 1870 MM. Popp and Resch established, first in Vienna and then in Paris, a system for regulating clocks by impulses of compressed air. At first in Paris there was a central station in the Rue Argenteuil with two small compressors delivering air into a receiver at two to three atmospheres pressure. In a second receiver air was maintained at a constant pressure of 1¼ atmospheres. Two clocks (one in reserve) actuated a distribution valve, allowing air to pass into the mains for 20 seconds in each minute. By means of small pipes, laid chiefly in the sewers, the air impulses were conveyed to the clocks which were to be regulated. At the clock a small bellows lifted a rod at each impulse and moved the escapement of the clock. The air mains were generally ⅜in. to ¾in. in diameter, and the service pipes into the houses ¼in. to ⅜in. in diameter. These pipes were extended over many miles, and in 1889 there were in Paris 8,000 clocks regulated by the pneumatic arrangements.

The system proved so successful that a new central station was erected in Rue St. Fargeau, in Belleville. Down to 1887, two small Farcot engines and a beam engine sufficed for the work.

Gradually there arose a demand to use the compressed air for small motors. An extension of the station was then made, and a second installation erected in the Rue St. Fargeau. This consisted of six Davey Paxman compound engines, each driving two compressing cylinders. The engines developed 2,000 h.p. The compressors were made in Switzerland, on the Blanchard system. Soon this plant became insufficient. A third installation was erected in the Rue St. Fargeau, in 1889. This consisted of five compound engines and compressors, built by the Société Cockerill, at Seraing, the compressors being on the Dubois-François system. These engines developed 2,000 h.p. Finally, another central station, at the Quai de la Gare, was erected, with engines of 8,000 h.p., and room for extension to 24,000 h.p. The engines are triple vertical engines, with Riedler compound compressors. The air is compressed so much more cheaply at the new station that the old station in the Rue St. Fargeau is no longer worked.[*]

At the St. Fargeau station neither the engines nor the compressors were of the best type. Their effect was to compress 265 cubic feet of air at atmospheric pressure to six atmospheres per indicated horse power hour. The cooling in the compressor cylinders was ineffective. The air from the six compressors was delivered into eight cylindrical receivers of 1,150 cubic feet capacity each.

The air was then distributed by cast-iron mains, 11·8in. in diameter. These had joints with indiarubber rings forming a kind of stuffing box, and permitting expansion at every pipe length without leakage. The mains are laid partly under roadways, and partly in sewer subways. They are supplied at intervals with automatic draining boxes. It was remarkable that the demand for power from this station so rapidly grew up to its full capacity.

The air motors used were generally of a simple kind. For small powers a simple rotary engine was used. For larger powers steam-engines were employed, worked with air instead of steam. Where the compressed air enters a building it generally passes through a screen which removes solid impurities. Then there is a stop valve and a meter for measuring the air. Next, there is often a reducing valve by which the pressure is reduced to 4½ atmospheres. In most cases there is a reheater, often a simple double walled box of cast iron, in which the air circulates, and is heated by a coke fire. For a 10 h.p. motor this reheater is about 21in. in diameter and 33in. high. The amount of coke used is not considerable, about ½lb. per horse-power hour. The air is raised in temperature to 300deg. F. The air motors are very convenient. They can be started at any moment, they are free from inconvenience from leakage, heat, or smell, and they require a minimum of attendance.

Often the exhaust can be used to cool and ventilate the working-rooms. The air motors are used for various purposes. At some of the theatres and restaurants they drive dynamos for electric lighting. At some of the newspaper offices there are motors of 50 h.p. and 100 h.p., driving printing machines. In workshops there are motors driving lathes, saws, polishing, grinding, sewing, and other machines. At the Bourse de Commerce, the compressed air drives dynamos for electric lighting, and also is used to produce cold in large refrigerating stores. In many of the restaurants air is used for cooling purposes. It is also used to work cranes and lifts directly, a water cushion being used between the working cylinder and the lift.

In the first compressors at the Rue St. Fargeau, about 265 cubic feet of air was compressed to six atmospheres per indicated horse-power hour. The second installation had somewhat better compressors. These compressed about 300 cubic feet of air per indicated horse-power hour.

Later, permission was given to Prof. Riedler to convert one of the Cockerill compressors into a compound compressor. After the change, 370 cubic feet of air were compressed to six atmospheres per indicated horse power hour. In the large new compressors at the Quai de la Gare, 438 cubic feet of air are compressed per indicated horse power hour. The general result of the working of the new station is that a cubic metre of air is compressed to seven atmospheres for 0·4 centime, or about four-tenths of the cost of compression at the older station.

In the new station the steam engines are vertical triple engines, working compound compressors with two low and one high pressure compressing cylinders. Each engine is of 2,000 h.p. Four have been erected, three being regularly worked and one kept in reserve. The new station has been placed on the banks of the Seine, where coal and condensing water can be obtained cheaply. Steam of 180lb. per square inch pressure is used, and the makers guaranteed that the engines would work with 1·54lb. of coal per indicated horse-power hour. The new air-main, about seven kilometres in length, is 20in. in diameter.

Compressed Air System at Offenbach, near Frankfort on Maine.—A compressed air distribution of the most improved type has been constructed at Offenbach by the firm of Riedinger, of Augsburg. The compressing station has a horizontal compound steam engine, with crankshaft and flywheel. The air compressors are compound, of Riedler's design. The air is compressed to two atmospheres in the first cylinder, and then to six atmospheres in the second. The heat is abstracted in an inter cooler between the high and low pressure cylinders. The steam cylinders are 22in. and 31in. diameter and 40in. stroke. Each air cylinder is worked direct from the back of the corresponding steam cylinder. The engine is stated to work with 15½lb. of steam per indicated horse-power hour, and the efficiency of the compressor is 87 per cent. The

* Howard Lectures delivered before the Society of Arts.

[*] For numerous details and data relating to the Paris system, see "Neue Erfahrung ueber die Kraft versorgung von Paris durch druckluft." Von A. Riedler, Berlin, 1891. "La Distribution de la force par l'air comprimé dans Paris," par Prof Riedler. Paris, 1891.

engine runs at 75 revolutions, or 490ft. of piston speed per minute. The air is distributed through 23,000ft. of cast-iron mains, with indiarubber ring joints. The main, when tested with a pressure of 6½ atmospheres kept up for 70 hours, showed a leakage of only 1·6 cubic feet per mile per hour.

Distribution of Power by Steam.

Most commonly where steam power is used, the boilers which generate the steam are near the engines which generate the power. But in special cases it has been necessary to convey the steam some distance before it is used in engines. Sometimes pumping machinery underground has been worked from steam boilers above ground by steam conveyed in pipes, protected as far as possible from heat losses by radiation. It would, nevertheless, hardly have been thought very reasonable to distribute steam widely for power purposes through pipes but for a secondary object. Steam distributed from a central station can be very conveniently used for heating purposes as well as for power purposes. The defects of steam as a means of distributing power may be balanced by its convenience as a means of distributing heat. At any rate, in America the experiment of distributing heat and power from a central station by steam has been tried on a very large scale, and with a considerable amount of success.

In 1877, Birdsill Holly took out a patent for a system of steam distribution for heating purposes only. The steam was carried in pipes, having anchored stuffing boxes at distances of 100ft., so that the expansion and contraction of the mains was provided for. The pipes were protected against radiation by asbestos and wood. Steam was distributed to each building through a reducing valve, and used at low pressure in heating coils in the ordinary way. The condensed steam was discharged through steam-traps into the sewers. Generally the condensed steam, before being discharged, was taken through coils in a chamber where the air entering the building was warmed, and the condensed steam reduced in temperature to about 100deg. Plants on this system were erected in many towns. In Lockport, for instance, in 1879, the main steam-pipes extended a distance of 16,000ft.

As early as 1869 Mr. Emery investigated the problem of distributing steam in New York,* and the result of his studies was the creation of the largest system of steam distribution hitherto erected. Mr. Emery concluded that steam could be economically distributed from one station to buildings within a radius of half a mile.

In New York 10 plots for stations were secured, and work commenced in 1881. So far as the author knows, there are now two steam stations in New York, a down-town station termed Station B in Greenwich-street, which has boilers working to about 16,000 h.p., and an up-town station in Fifty-eighth street, designed for boilers of 3,000 h.p., and having about half this power at work.

The pipes from the down-town station extend through about 5½ miles of streets; those from the up-town station through 2¼ miles of streets. They work with steam at 80lb. to 90lb. pressure per square inch. The main pipes are of wrought iron, 16in., 15in., 13in., and 11in. in diameter outside, and about ½in. less in diameter inside. Return mains were also laid for the condensed water. These were 6in. and 8in. in diameter near the stations, decreasing to 4in., and even to 2½in., towards the ends of the pipe lines. More recently the return mains have been disused on account of their rapid corrosion.

The steam is used for a great variety of purposes, in addition to the principal purpose of warming buildings. It is used for driving engines for various manufacturing purposes, for driving engines for electric lighting, for engines working lifts, and for engines for ventilation. In 1887 there were some 500 engines worked with steam from Station B.

Prevention of Loss by Heat Radiation.—To prevent loss by radiation, the pipe is surrounded by non-conducting material. For this purpose, in different cases very different materials have been used. Straw laid parallel to the pipes, and covered with loam, is effective; but there have been used felt, cork, fossil meal, *papier mâché*, slag wool, and asbestos. Slag wool, obtained by blowing superheated steam through molten slag, is exceedingly efficacious, from the large amount of air it retains in the interstices of the wool; but if it gets moist, the sulphur it contains causes rapid corrosion of the iron pipes. Probably, with any of the coverings mentioned, moisture would also be very injurious.† It is, therefore, important to keep the outside of covered pipes dry, and this is best secured when the pipes are kept continuously heated.

In the case of the New York steam supply, the pipes are laid in brick trenches, the brickwork being kept 4in. away from the pipes. The pipes were coated with hot asphalte varnish, and the space packed with slag wool. Over the pipes a roof of short planks smeared with tar and bedded in cement is used, and a covering of tarred paper over the planks was carried well down the side walls to exclude percolating moisture.

The general arrangement of the pipes is to have an expansion joint every 50ft., and two intermediate joints, all the joints being carried on brick piers with a stone cap. At all dips in the pipe traps are connected for discharging the condensed steam.

Quantity of Power Transmitted by Steam-mains.—It is assumed that the velocity in the mains is u, and v is the specific volume of the steam, then the weight in pounds of steam transmitted per second, in a pipe of section Ω square feet, is

$$W = \frac{u}{v}\Omega;$$

if we take $u = 80$ft. per second,

$$W = c\,\Omega,$$

where c is a constant for any pressure.

Gauge pressure.	Absolute pressure.	v Cubic feet per lb.	c
lbs. per sq. in.	lbs. per sq. in.		
45	60	7·04	11·36
75	90	4·81	16·63
125	140	[illegible]	25·15

Suppose that, in accordance with Mr. Emery's estimate, 30lb. of steam per hour is taken to furnish an indicated horse power in ordinary engines. Then the horse power transmitted will be 120 W.

Diameter of main in inches.	Steam-gauge pressure.	Weight of steam conveyed.	H.P. transmitted by main.
	lbs. per sq. in.	lbs. per sec.	
6	45	2·23	267
,,	75	3·26	391
,,	125	4·93	592
12	45	8·92	1,070
,,	75	13·05	1,570
,,	125	19·74	2,370
18	45	20·07	2,410
,,	75	29·38	3,530
,,	125	44·45	5,330

These figures are, necessarily, rough values. But they show that with steam very large amounts of power can be transmitted, without sensible pressure loss, through mains of moderate size.

LECTURE VI.

Distribution of Power by Gas and by Electricity.

Distribution of Gas for Power Purposes.—The distribution of gas for power purposes involves nothing new or untried. Coal gas is manufactured on an enormous scale, and distributed widely over extensive town districts. In the United Kingdom there has been expended on capital account in gas undertakings a sum of £60,000,000. The amount of coal carbonised annually is 10,000,000 tons, and the quantity of gas manufactured is 98,000 million cubic feet. If there were a demand for gas for heating and power purposes, there is no likelihood of failure of ability to supply and distribute it. Coal gas is already in many towns used on a considerable scale for heating and motive power. Mr. Trewby, the president of the Institute of Gas Engineers, estimates that, in the London district alone, there are 70,000 gas cooking and heating stoves and 2,500 gas engines.

Gas distribution has one distinctive advantage over compressed air or electricity distribution—namely, that the manufacture is carried on continuously through the 24 hours, the fluctuations of demand being met by storage, which is neither difficult nor expensive.

There is no reason to think that the cost of ordinary lighting gas is so high as to preclude its use on a considerable scale for power purposes. Taking the cost of lighting gas at 2s. to 3s. per 1,000 cubic feet, and the consumption of a gas-engine, on an ordinarily varying load, at 26½ cubic feet per hour per horse-power, the cost of the power for gas, exclusive of interest on the gas engine, comes to £8 to £12 per horse power per year of 3,000 working hours.

But the cost at which lighting gas is sold includes interest on a vast network of mains and the loss due to leakage over an extensive area. This part of the cost is not fairly chargeable against gas used for power purposes. In an installation for power the system of mains would be far simpler than in a distribution for lighting. With a comparatively few consumers taking comparatively large quantities of gas at a steady rate throughout the year, all the interest and depreciation charges would be smaller than those incurred in a distribution of lighting gas to a multitude of comparatively small consumers. It appears that the cost of the manufacture of coal gas, including coal, wages, and petty stores, is about 10d. per 1,000 cubic feet. Probably 18d. per 1,000 cubic feet would allow sufficient margin for profit and cost of distribution to power consumers in a manufacturing quarter not unfavourably distant from the generating works. But at that cost per 1,000 cubic feet the cost of the power would be only £6 per effective horse-power per annum. The charge for interest and depreciation on the motor plant and for wages would not add to this more than £3, making the total cost to the consumer £9 per effective horse power per annum.

Central Electric Lighting Station at Dessau.—This station, where the motive power is produced from gas engines worked with lighting gas, has been sufficiently successful to show that such a method of obtaining power is commercially possible. The station

* Emery on "District Distribution of Steam in the United States." *Proceedings* Institution of Civil Engineers, vol. xcvii.

† *Proceedings*, American Society of Civil Engineers, vol. xii., p. 263.

TABLE A.—Density and Calorific Value of Gas.

—	Cubic feet per pound.	Calorific value. Thermal units. Per cubic foot.	Calorific value. Thermal units. Per pound.	Oxygen required for combustion per cubic foot in cubic feet.	Oxygen required for combustion per pound in pounds.	Volume of products of combustion with air in cubic feet, per cubic foot.
Manchester gas	—	—	—	1·229	—	6·29
American gas	26·5	[illegible]	16,326	1·320	—	—
London gas	33·7	617	20,801	1·157	3·38	—
Petroleum	—	—	20,363	—	3·35	—
Pittsburgh gas	24·75	883	20,610	1·48	3·27	7·50
London gas	30·3	633	19,199	1·24	3·35	—
Dowson gas	14·80	160	—	0·24	0·32	2·74
Water gas (a)	26·0	284	7,373	—	—	—
„ „ (b)	20·8	640	13,317	—	—	—

(a) Not carburetted. (b) Carburetted.

installation consists of two two-cylinder (Otto system) gas-engines of 60 h.p. each, one single-cylinder engine of 30 h.p., and one of 8 h.p. The group of engines work to about 160 effective horse-power. Directly coupled to these are dynamos of corresponding power. The 8 h.p. engine is used for daywork and for starting the larger engines. The jacket water is cooled by air coolers and used over again. There are 1,076 square feet of cooling surface. An injector, worked by pressure-water from the town mains, circulates air through the coolers. The water consumption is thus reduced to five gallons per horse power hour for all purposes.

In an electric station, gas-engines have the advantage that they can be started and stopped when required, and have no stand by losses like those of steam boilers. At Dessau, a large accumulator battery is used for storing energy when the engines supply in excess of the demand, and restoring it in hours of small demand. The efficiency of the battery on the average of the year is 79 per cent. About 52 per cent. of the whole supply passes through the battery, so that the waste of current due to the battery is about 11 per cent. of the total yearly supply.

The average gas consumption of the motors is 26½ cubic feet per effective horse-power hour. Motors of varying power were adopted with an idea that they would best meet a varying demand. The constructors of the station now think that the accumulator battery renders this unnecessary, and that motors of a larger and uniform size would be more economical. They claim, as advantages of a gas plant compared with a steam plant, that less space and less water is required; that there is absence of smoke and danger of explosion; and that gas stations can be distributed more easily over the area to be supplied.

Distribution of Natural Gas at Pittsburgh, U.S.A.—A remarkable case of distribution of gas for heating and power purposes has been in operation at Pittsburgh.* The natural gas has entirely taken the place of coal in manufactories and for domestic heating in a district where coal is exceedingly cheap. Coal could be obtained at Pittsburgh for 4s. to 5s. a ton, and coal slack at 2s. to 2s. 6d. a ton.

The natural gas was met with in boring for oil, and was first used to raise steam for the oil pumping engines. At 18 miles from Pittsburgh an enormous outburst of gas occurred, which, for five years, was allowed to burn to waste. Then a company engaged to take it a distance of nine miles to Messrs. Carnegie's works. They were to be paid for the gas the value of its equivalent in coal until the capital cost of the pipes was repaid. After that, the gas was to be supplied at half the cost of its equivalent in coal. In 18 months the cost of the pipes was repaid, and the gas was then supplied at half the cost of its equivalent in coal. It was then conveyed into Pittsburgh and still greater distances. When Mr. Carnegie described the operations, there were 11 gas-mains, of 6in. to 12in. diameter, conveying gas to Pittsburgh.

The largest well discharged 30,000,000 cubic feet per day, and other wells half that quantity. At the wells the gas had a pressure of 200lb. per square inch; and at Messrs. Carnegie's works, nine miles distant, the pressure was 75lb. per square inch. This gave rise to difficulties from leakage, and it was found desirable to reduce the pressure in the pipes in towns, and even to place ventilating pipes at every joint in the mains, leading the leakage above the level of the street lamps. In using natural gas one fireman can manage boilers developing 1,500 h.p.

Other Gas Supplies for Heating and Power.—A cheaper gas than lighting gas can be manufactured for heating and power purposes. 1. So called "water gas," obtained by injecting superheated steam through incandescent anthracite or gas coke. Such gas has a volume of about 26 cubic feet to the pound, and develops about 7,373 thermal units F. per pound. 2. Dowson gas, made by passing air and steam through incandescent coal or coke. This gas contains a large amount of nitrogen, with the hydrogen and oxide of carbon. Four volumes of it are about equal in calorific value to a volume of lighting gas. It develops 160 thermal units per cubic foot. With anthracite at 13s. a ton, Dowson gas costs about 2d. per 1,000 cubic feet, exclusive of interest and depreciation on plant. 3. Mr. Thwaite has proposed for power purposes a gas of about 12 c.p., obtained by mixing lighting gas and producer gas. Such gas can be manufactured for 4d. per 1,000 cubic feet, and could be distributed and sold profitably for 16d. per 1,000 cubic feet. Its calorific value is little lower than that of lighting gas.

* See a paper by Mr. Andrew Carnegie on "Natural Gas," read before the Iron and Steel Institute.

The preceding table (A) contains data about various qualities of gas.

(*To be continued.*)

COMPANIES' REPORTS.

HOVE ELECTRIC LIGHTING COMPANY, LIMITED.

Directors: Colonel A. J. Filgate, R.E., chairman; Colonel H. Wood, C.B., vice chairman; Harold A. Hoare, Esq.; Carleton F. Tufnell, Esq.; John Wilkes, Esq.

First report of the Directors to be presented at the annual general meeting of the shareholders at the Town Hall, Hove, on Tuesday, December 12, 1893, at 3 p.m.

The Directors have pleasure in submitting their first report, and in congratulating the shareholders upon the success which has attended the operations of the Company to the present date. By the terms of the contract with the Hove Commissioners, approved by the Board of Trade, it is stipulated that the first annual balance-sheet of the Company shall be made up to the 31st December, 1893, but under the articles of association, a general meeting of the Company must be held in each year, when accounts made up to the latest convenient date have to be presented to the shareholders. With the view of complying with this latter requirement, the Directors now lay before the shareholders a balance sheet and profit and loss account made up to the 30th September last, duly audited, and which they propose shall be considered merely as an interim statement, to be superseded early next year by the accounts up to the 31st December next, prepared in the form required by the Board of Trade. It will be seen from the accounts attached to this report that the result of working up to the 30th September, after debiting to revenue a proper proportion of the administration charges from the 1st January, when the lighting was practically commenced, is a debit balance of £264. 10s., a result which, in a new enterprise, must be considered as satisfactory. Since about the middle of September, the working account shows a steadily increasing net profit each week, and the balance of the debit of the profit and loss account on 30th September has since been reduced considerably, and the Directors have every reason to anticipate that this balance will soon disappear. The contract with Messrs. Crompton and Co., Limited, was sealed on August 19, 1892, and by the 28th November following a temporary station had been erected, wherein were installed the necessary plant and machinery, a considerable length of permanent mains had been laid in culverts and casing, and the supply of electric current to the public was commenced, and has continued ever since without interruption. Since that date, the mains have been extended in various directions to meet the public demand, until the total length now laid exceeds 6½ miles. The erection of the permanent station by the contractors is rapidly approaching completion. A number of houses and buildings connected up to the Company's mains is 82, and, including the arc lamps and sockets, the number of lamps attached to the system is equal to 6,169 of 8 c.p. The applications for the light are steadily increasing, and it is confidently expected that the Company will soon be doing a large and remunerative business. From the station report of the 23rd November, the net profits of the Company, after providing for all administration and other charges, amounted to £18. 15s. for the week. It will be observed that on the 30th September last, the Company had issued 3,290 shares, and a few more have since been taken up, but the large amount due to contractors and others makes it a matter of urgent necessity that further capital should be obtained forthwith. The Directors have appointed Mr. Robert Payne (chartered accountant) to be the auditor of the Company, and it is proposed that he shall submit himself for re-election at the general meeting to be held early next year.

Balance sheet, Sept. 30, 1893.

Capital and Liabilities.	£	s.	d.
Authorised issue, 8,000 shares £5 each	40,000	0	0
3,290 shares issued at £5, £16,450; less arrears, £206	16,244	0	0
Loan from bankers	2,500	0	0
Consumers' deposit account	3	0	0
Due to contractors and others	8,565	3	10
	£27,312	3	10

Property and Assets.

	£	s.	d.
Electric generating station, mains, plant, machinery, and instruments (cost to date)	24,761	16	10
Meters, etc.	583	4	0
Office furniture and fixtures	69	4	11
Sundry debtors for current, meter rents, etc.	301	14	8
Preliminary expenses, including legal and other costs attendant upon the transfer of the Hove electric lighting order and installation suspense account	908	7	10
Cash at bankers and in office	423	5	7
Profit and loss account balance	264	10	0
	£27,312	3	10

PROFIT AND LOSS ACCOUNT, SEPT. 30, 1893.	£	s.	d.
Wages at station and engineer's superintendence	308	1	4
Fuel, water, and stores	130	10	10
Rent, rates, and insurance	110	6	11
Stationery, printing, and general expenses	81	17	3
Directors' fees and salaries (proportion of)	222	18	7
Interest on loans	27	18	11
	£881	13	10

	£	s.	d.
Current sold, and public lighting	574	13	6
Meter rents	42	10	4
Balance, net loss to date	264	10	0
	£881	13	10

BUSINESS NOTES.

South Wales.—The towns of Aberystwith and Lampeter propose to introduce the electric light.

Great Northern Telegraph Company.—For the month of November the receipts were £21,600.

Western and Brazilian Telegraph Company.—The receipts for the week ended December 1 were £3,460.

Commercial Cable Company.—A quarterly dividend of 1¾ per cent., payable on the 2nd prox., has been declared.

Shanklin.—A committee has been appointed by the Local Board to consider the subject of electrically lighting the town.

Direct Spanish Telegraph Company.—The receipts for the month of November were £305 more than for the corresponding period.

Cuba Submarine Telegraph Company.—The receipts for the month of November were £38 more than for the corresponding period.

Eastern Telegraph Company.—The receipts for the month of November were £60,995, as against £60,491 for the corresponding period.

Blackburn.—It is proposed to erect new gasworks, and then the site of No. 1 gasworks will be used for electric lighting purposes.

Derby.—A joint sub-committee has been appointed from the Highways and Electric Lighting Committees as to street lighting by electricity.

Eastern Extension Telegraph Company.—For the month of November the receipts show a decrease of £604 as compared with the corresponding period.

Manchester.—The Lord Mayor, Aldermen Sir J. J. Harwood, Leech, Milling, and Councillor Southern have been appointed a special sub-committee in reference to telephones.

High Wycombe.—A committee of the Town Council has been nominated to deal with the provisional order, for which an application has been made to the Board of Trade.

The Blackpool Cars.—The Town Council have resolved to operate the tramcars by horses for a period of about three months, until some definite scheme can be pushed through the Council.

Charge of Embezzlement.—Mr. Henry Hunt, manager of the Taunton electric light works, has been arrested on a charge of forgery and embezzlement. He has been remanded until to-day.

Electric Railways in Japan.—A line is proposed to be built by American enterprise from Tokio to Yokohama, 30 miles long, connecting with a network of branch lines at both ends in these cities.

Swansea.—The Electric Lighting Committee of the Corporation were engaged on Tuesday in further considering the question of the electric lighting of the borough. Mr. Manville is advising the committee on the subject.

Tenders Accepted.—The following tenders were received for electric lighting and gasfitting at The Green Man, Bucklersbury, City: Christian, £104; Pragnell, £73. 10s.; Winn, £66. 15s. The tender of Mr. Winn has been accepted.

Bradford.—The members of the Gas and Electricity Supply Committee of the Corporation made their annual inspection on Tuesday of the premises used by the Corporation for the manufacture of gas and the generation of electricity.

Something Made Out of Telegraphy.—The value has been sworn at £83,965 of the personal estate of Mr. Henry Edward Weaver, late managing director of the Anglo-American Telegraph Company, and formerly secretary to the Electric and International Telegraph Company.

Sunderland.—In our last issue, in referring to the Sunderland tenders, it was erroneously mentioned that the amount of the tender of Messrs. C. A. Parsons and Co. for the whole of the work was £19,044. We are informed that the total sum should have been given as £14,052.

City and South London Railway Company.—The receipts for the week ending December 3 were £902, against £907 for the same period last year, or a decrease of £5. The total receipts for the second half year of 1893 show an increase of £178 over those for the corresponding period of 1892.

Eccles.—Alderman Kendall, who moved the adoption of the minutes of the Tramways and Electric Lighting Committee, at a meeting of the Town Council a few days ago, stated that the committee would at its next meeting discuss the advisability of taking steps to light certain portions of the borough with the electric light.

Lighting of Hammersmith.—The Vestry have decided that a scheme should be prepared for the electric lighting of the parish. Messrs. Morgan, Williams, and King, of Westminster, have been instructed to prepare, for the sum of 100 guineas, a report for the carrying into effect of the terms of the recently obtained provisional order.

Londonderry.—The Town Council have practically completed the electric light station. The contract for the electrical work has been carried out by Messrs. Siemens Bros. and Co. The Town Council, as will be seen from our advertisement columns, require the services of a chief engineer, an engine man and assistant, and a dynamo tender.

York.—It was mentioned at a meeting of the York City Council on Monday, that communications had been received from electric lighting companies inviting the Streets and Buildings Committee to inspect works and stations. It was stated that it was the intention of the committee to visit the lighting stations at the expense of the Corporation.

Huddersfield.—The School Board has adopted the electric light, which was brought into use at the offices for the first time on Monday. The Huddersfield Industrial Society have instructed the Managing Committee to light the premises of the central stores by electricity at an estimated cost of £1,600, provision being made for 550 lamps.

Bolton.—The Technical Instruction Committee of the Town Council have requested Alderman Miles, J.P., the chairman, to lay the foundation stone of the electricity buildings on Spa road, at a date to be fixed. They have likewise accepted the tender of Messrs. Edison Swan and Co. for switchboards, and that of Messrs. Crompton and Co., London, for accumulators.

Appointment Open.—Sir Edmund Hay Currie, of Currie Schools, Folkestone, requires a science master to teach physics only; must be a specialist with high honours at English or German university. The teaching comprises general and scholarship work and that connected with technical applications; practical work important; physical and electrical laboratories; exceptional opportunities for research; liberal salary.

Ruthin.—Mr. John Roberts in the course of the discussion on the formation of the committees asked, at a recent meeting of the Town Council, whether the Electric Lighting Committee had been called. Certain instructions were given that a committee should be called and they had been neglected up to now. The Clerk said he wanted to call a committee. He had a lot of correspondence to put before the Council.

Appointments.—Mr. Cuthbert Moore was recently appointed electrician on board the P. and O. steamship "Ganges." Mr. D. Bergin has been nominated electrician in the White Star Line. Mr. W. C. Thomson has been engaged as second engineer to the Westminster Supply Company, Eccleston-square station. All three qualified themselves as electrical engineers under Mr. Ronald Scott, M.R.I., M.I.E.E., Acton-hill, London, W.

Dudley.—In moving the adoption of the report of the Streets and Gas Committee, at a meeting of the Town Council, Alderman Bagott referred to the question of the electric light. He remarked that out of 60 towns in respect to which applications had been made for orders for the introduction of the electric light only four had put them into operation, the other 56 remaining dormant and watchful, which was a policy he recommended the Council to adopt for the present.

Hastings.—The Roads Committee of the Town Council have received an application from the Electric Light Company, Limited, on behalf of Messrs. Barrance and Ford, for permission to put up a projecting outside removable electric lamp at their premises at Claremont, and they recommended that the application be granted. The committee have also received other applications, which, together with the first-mentioned, have been granted.

St. Helens.—A sub-committee (comprising Aldermen Cook, J. C. Gamble, and M'Kechnie, and Councillors Dixon Nuttall, Beecham, and Forster) has been appointed to consider the provision of a supply of electricity within the borough, and the various methods suggested from time to time for enriching the illuminating power of the gas without increasing the cost. The St. Helens Town Council decided on Wednesday to apply to the Board of Trade for a provisional order to supply electricity for public and private purposes.

Swindon.—Tenders are invited by the New Town Local Board by the 11th inst. for the following: (1) The supply of gas, oil, or electric light to and lighting and cleaning of all lamps within the district of Swindon New Town for one year, commencing January 1; (2) the supply of gas, oil, or electric light only for all lamps within the district for one year, commencing January 1; (3) for the lighting and cleaning of all lamps within the district for one

year, commencing January 1. Tenders are to be delivered to Mr. H. Kinneir, clerk, Public Offices, Swindon

Salisbury.—Electric light installations have recently been put up on the premises of Messrs. S. Parker, Laming, and M. Parker, of Catherine-street. The current is obtained from a Tyne dynamo, driven by a 6½ h.p. gas-engine. Outside Mr. S. Parker's and Mr. Laming's establishments there are two 1,000-c.p. arc lamps. On the opposite side of the street Mr. M. Parker has three lamps of 200 c.p. Overhead wires connect the two sets of lights. The interior of each place of business is lighted by a number of 16-c.p. lamps. The installations have been carried out by Messrs. Roger Dawson and Co.

Aberdeen. The governors of Robert Gordon's College have approved the report of the Education Committee, who stated that they had before them the remit from the quarterly general court in regard to the question of the electric lighting of the college, with special reference to the proposals at present under the consideration of the Town Council for lighting the city by electricity. In view of the fact that the area adopted by the Town Council included School-hill, it was agreed to consult the official in charge of the works as to lighting the college buildings and the school of art from the Council's mains.

Lighting at Notting Hill.—The Highways Committee of the London County Council reported on Tuesday that two notices had been given by the Notting Hill Electric Lighting Company for mains across Campden-hill-road and along a part of Bedford-gardens, and for mains in Campden-hill-road and a short distance in Kensington High-street. The committee recommended that the sanction of the Council be given to the works referred to in two notices on condition that the company give two days' notice to the Council's engineer before commencing the works, and that the boxes be of a pattern approved by the Council.

Scenic Theatre.—The interesting display that was made by Messrs. Siemens Bros. at their little model theatre in the Crystal Palace Electrical Exhibition gave rise to an amount of eagerness on the part of the public everywhere to see the show and the similar device erected at the Chicago World's Fair has proved even more of a success. "After the fair is over," the model has now been moved to San Francisco, where, at the Midwinter Exposition, the energetic Western Electric Company (who secured the American rights of the arrangement) are continuing to give the public at large a liberal and interesting education in the possibilities of artistic and effective electric lighting.

Lighting in Oxford-street.—The Highways Committee of the London County Council reported on Tuesday that the St. James and Pall Mall Electric Light Company had given notice of intention to lay mains in Berwick-street from Oxford-street to Portland-street, with a crossing at Noel-street. The committee recommended that the sanction of the Council be given to the works referred to on condition that the company give two days' notice to the Council's engineer before commencing the works; that the covers of the street boxes be supported on 3in. York stone; and that before any street boxes are constructed the designs for and the proposed positions of them be submitted to and approved by the Council's engineer.

Chelsea v. London Electric.—In the Court of Appeal on Wednesday, before Lords Justices Lindley, A. L. Smith, and Davey, the case of the Chelsea Electric Supply Company, Limited, v. the London Electric Supply Corporation, Limited, was decided. On the 23rd of August Mr. Justice Wright made an order restraining the defendants in this action from laying down mains within a statutory area except in accordance with an agreement between the parties, and from that order the defendants appealed. Mr. Butcher, who appeared for the appellants, stated that the plaintiffs now admitted that the mains as laid by the defendants were in accordance with the agreement, and since the appeal was lodged the parties had come to terms. An order was accordingly made in the terms arranged.

Situations Vacant.—The Manchester Corporation require an experienced foreman, accustomed to dealing with workmen and competent to undertake all classes of cable work, bare copper strip, couplings, connections, attachments of leads and appliances. The Corporation also require several first-class vulcanised rubber cutters and jointers, well trained for coupling box and street tent work; and a person of good theoretical knowledge and previous experience of central-station work required as meter inspector, tester, and competent to do all connection work on consumer's premises, and to act as townsman generally. Application to be made to the Chairman, Gas Committee, Town Hall, Manchester, stating past experience, full details, and wages required for the vulcanised jointers per hour, and two other positions wages per week.

Charges for Current at Scarborough. The success which has attended the introduction of the electric light, and a desire on the part of the directors of the Scarborough Electric Supply Company, Limited, to encourage further extensions, have induced the Company to reduce their scale of charges. The charge per Board of Trade unit for electrical energy now varies with the number of units consumed in each quarter, in accordance with the following scale: Not exceeding 200 units, 6½d. per unit; exceeding 200 and not exceeding 400 units, 6¼d.; exceeding 400, and not exceeding 800 units, 6d.; exceeding 800 units, 5¾d. The charge for meter rent is 2s. per quarter for any number of lights not exceeding the equivalent of 50 8-c.p. 35-watt lamps, with 6d. extra per quarter for every additional 25 such lamps or their equivalent connected.

Derby.—Tenders are invited by the 16th inst. for the wiring, fittings, etc., for the various public buildings on the electric lighting area, for the Corporation—viz., Market Hall, Town Hall, Babington-lane offices, Full-street baths, weights and measures inspector's house, police stations, and fire brigade station, Derby. Specification and form of tender, containing plans, schedule of rooms, route of mains, etc., may be had on deposit of £1. 1s. (which will be returned on receipt of a *bonâ fide* tender), and particulars obtained on application to Mr. R. J. Harrison, borough engineer, Babington-lane, Derby. Tenders, endorsed "Wiring, etc., Public Buildings," to be sent to Mr. H. F. Gadsby, town clerk, Town Hall, Derby. The Rev. Dr. Macdonald, pastor of the Presbyterian Church, Greenhill, has undertaken to defray the cost of lighting that building by electricity. The cost will be about £120.

Fined for Defective 'Bus-Lighting.—Mr. Kingham, secretary to the London General Omnibus Company, was summoned at the Bow-street Police Court last week for allowing six omnibuses to be in a public thoroughfare after sunset without a light. Mr. W. Hicks, who appeared for the company, pleaded "Guilty" on their behalf. He explained that the vehicles complained of were fitted with the electric light, which answered admirably in the summer but proved a failure in the winter. The difficulty had been caused by an insufficiency of batteries which took about six or seven hours to charge. A new contract had now been entered into; the contractors would supply spare batteries, and would be liable to severe penalties if the light failed. Under these circumstances, he hoped the magistrate would impose a merely nominal fine. Sir John Bridge fined the company 1s. and costs in respect of each of the six carriages.

Town Refuse and Electric Lighting.—An interesting exhibition is now being shown at Halifax for the purpose of demonstrating the feasibility of generating steam for electric lighting, etc., with ashbin refuse as the only fuel. The installation, appropriate to the Northern Engineering Company, Limited, Parkinson-lane, consists of Livet's expanding flue steam generators (two-furnaced) capable of giving 300 h.p. when town refuse is burnt. The electrical plant comprises a powerful Parsons turbo electric generator, which energises a search light of 25,000 c.p., and a full complement of arc lamps. It is claimed that these steam generators, instead of simply destroying the refuse, utilise it to the fullest advantage by turning it into steam which can be used for a variety of purposes. This exhibition will prove not only interesting but also that it is possible to produce in any city the electric light at a low cost by simply burning rubbish.

Elmore's French Copper Company.—The creditors and shareholders of Elmore's French Patent Copper Depositing Company, Limited, met on Tuesday at the Holborn Restaurant before Mr. C. J. Stewart, official receiver. Mr. J. H. Duncan, the receiver for the debenture holders, reported that the property (excepting the Bellegarde land and the London assets) had been sold for £8,600 in cash, £60,000 in first mortgage French obligations, and 5,000 founders' shares. Further, that a scheme was being arranged whereby the debenture holders would accept payment in the French obligations; the claim of the Foreign and Colonial Company (who were the promoters of the French company) would be deferred; and the present unsecured creditors would become entitled to the first mortgage debentures of the resuscitated company. The Chairman pointed out that the Company expended £320,638 for the patents and upon the works, and yet the best offer that could now be obtained was £73,600, to be paid in cash obligations and founders' shares. Eventually, the meetings were adjourned to enable the scheme to be finally settled and submitted.

Electric Lighting Notices.—The following is a list of the applications made to the Board of Trade for the ensuing session: Aberdare Electric Lighting (P.O.); Bedford Electric Lighting (P.O.); Birmingham Electric Lighting and Power (P.O.); Brixton Electric Lighting (P.O.); Barrow-in-Furness Corporation Electric Lighting (P.O.); Chepping Wycomb Corporation Electric Lighting (P.O.); Camberwell Electric Lighting (P.O.); Chelmsford Electric Lighting (P.O.); Chesterfield Electric Lighting (P.O.); Collier Marr Moss Side Electric Lighting (P.O.); Crystal Palace District Electric Lighting (P.O.); Corporation of Clonmel Electric Lighting (P.O.); Guildford Electric Lighting (P.O.); Grimsby Electric Lighting (P.O.); Harrow Electric Lighting (P.O.); Lynton Local Board Electric Lighting (P.O.); Monmouth Electric Lighting (P.O.); Oswestry Electric Supply; Penrith Electric Lighting (P.O.); Plymouth Corporation Electric Lighting (P.O.); St. Austell Electric Lighting (P.O.); Swansea Electric Lighting (P.O.); Shrewsbury Electric Lighting (P.O.); Stirling Electric Lighting (P.O.); Wakefield Corporation Electric Lighting (P.O.); West Hartlepool Electric Lighting (P.O.); Yeadon Electric Lighting (P.O.).

Bankruptcy Proceedings.—At the Nottingham Bankruptcy Court the case of Mr. William Andrews, electrician, lately carrying on business at 118, Hanger Hill-road, Nottingham, was considered last week. Mr. Berryman appeared for the debtor. The Official Receiver said the examination had been adjourned from a previous Court in order that the debtor might deliver an account to the trustee of the money expended by him during the 12 months preceding the 29th of September, the date of the receiving order. The debtor had rendered an account, but it was not regarded by the trustee and himself as being satisfactory. It went very far from accounting for the sum of £900 which he admitted at his examination he had received within a period of two years, he believed, from the time of his bankruptcy. It was to be observed, however, that the debtor had not kept any books, and there seemed no probability of being able to obtain from him any account which would be more definite than the one before them. Therefore, the trustee was disposed, and he (the official receiver) was of the same opinion, to offer no objection to the debtor

passing his examination. The examination was then closed, debtor being allowed to pass.

Assessment of Electric Light Companies.—At a meeting of the City of London Union on Tuesday, Mr. Klenck drew attention to the electric lighting companies within the City and as to their assessment. It appeared that there were several of these companies carrying on business in different parts of London, but what more immediately concerned that Board and what he wished to know was whether the Assessment Committee of the City of London Union had proceeded to assess the electric lighting companies within the bounds or area of the City? Many of the traders and shopkeepers were complaining of having to pay such heavy rates, and he did not see why, if any revenue could be obtained from these companies, they should be allowed to go scot free, and the sooner they took cognisance of the presence and existence of these bodies in their midst, and at the same time made them contribute their quota to the City rates, the better it would be for the parochial exchequer and for alleviating the burden on the already heavily pressed ratepayers. Mr Odell, as chairman of the Assessment Committee, assured Mr. Klenck that the subject to which he had called attention was receiving attention.

Action regarding Bills of Exchange.—An action was decided in the Lord Mayor's Court on the 1st inst., in which Mr. Frank Urch sought to recover from Mr. M. Greenhill, an electrical engineer, of Mansion House-chambers, the sum of £23, the balance of principal alleged to be due upon two bills of exchange for £25 and £14 respectively, and the costs of a judgment paid by the plaintiff in respect of the said bills. Mr. Moses (instructed by Mr. Emanuel) was counsel for the plaintiff, and Mr. Sturgess (instructed by Mr. Edwards, for the defendant. The bills were drawn by the defendant and accepted by the plaintiff, and were discounted by a bill discounter named Talbot. Mr Talbot subsequently sued the plaintiff and defendant on the bills, and obtained a joint judgment against them, which had been satisfied by the plaintiff. Now the plaintiff sought to recover from the drawer his contribution of the total expense. The defendant declined to pay, firstly, because there had been no notice of dishonour, and, secondly, because the bills were drawn for the accommodation of the acceptor, who received the whole of the money less the charges for discounting. The jury found for the plaintiff, for whom judgment was entered, subject to a reference of the figures to the registrar.

Workington.—In a communication to a West Cumberland paper on the subject of water power, Mr F. Freeston says: "It is a well-known fact that our River Derwent is one of the quickest flowing rivers in England. And why allow her to deliver all her power into the mighty ocean without doing something for her guardian? Now just let me point out one place where a start can be made as a foundation for our noble river to help us—say, the millfield of Workington. Now for the work and distribution of power. First lay down very powerful turbines in order to give the river a chance. Say six at 4,000 h.p. each. Connect these turbines to very powerful alternating current dynamos. This power must now be distributed in order to benefit everybody. Lead electric cables—underground and overhead—to adjoining towns and villages, steelworks, ironworks and factories, railway and tramways, sawmills and flour mills, brickworks and collieries, farm houses and dwelling houses, main streets and turnpikes. Then those who want light will get it at a cheaper rate than gas. Then there shall be better health and more strength and prosperity. I may mention that electricity has developed so far even now that the people of Workington need not fear a trial. Let us make the public at large understand that there is someone willing to put his shoulder to the wheel in order to revive matters in Workington.

Coventry.—The Electric Light Committee of the Town Council have presented a report to the Council stating that they had called in Mr. A. H. Preece, of Westminster, to advise them, and submitted to him the tenders of the Brush Electrical Engineering Company, Limited, and Messrs. Hammond and Co. with John Fowler and Co. (Leeds), Limited. Mr. Preece reported that, after making certain additions to and deductions from the tenders, in order to reduce them to a common basis, that of Messrs. Hammond and Fowler was the lower by £278, and he recommended its acceptance, subject to certain small modifications to which Messrs. Hammond and Fowler have agreed. Mr Preece also recommended that, for the purpose of supplying current at times of light load a small plant of 15 kilowatt capacity should be added to the equipment of the station. The committee received an offer from Mr. Robert Hammond, associated with Messrs. Fowler in this matter, to retire from the contract to act as consulting engineer to the Corporation, at a commission of 5 per cent., the contract being placed with Messrs. Fowler and Co. at 5 per cent. less than the figure named in the tender. To this Messrs. Fowler are ready to agree. The committee recommend that this arrangement be carried out. The committee accordingly recommend that the tender of Messrs. Fowler be accepted, subject to their entering into a proper contract, and guaranteeing the efficiency of the generating plant to be not less than 75 per cent. at full load. The acceptance will also be subject to the sanction of the Local Government Board to the necessary loan. The amount of the tender as it stands is £8,843 6s. To this must be added the cost of trenching the streets, and of the small plant above mentioned, about £1,000 in all. There are also the purchase money of the site, the cost of buildings and the wages of the clerk of the works. While not anticipating that the estimate of £15,000 will be exceeded, the committee recommend that application be made for sanction to a loan of £20,000.

Lighting of Larne.—The principal business at the last meeting of the Town Commissioners was the consideration of tenders for the lighting of the town. The Chairman stated that they had received two tenders—one from the electric light company (the present contractors), and the other from the gas company. He would call on the clerk to read the tenders, and it was for the Board to decide in the matter. The clerk then read the tender and specification of the electric company, in which they offered to light the town with 11 arc lamps of 1,200 c.p. at £11 each per annum, six incandescent lamps of 32 c.p. £4 each per annum, 66 incandescent lamps 16 c.p. at £2 each per annum for the term of three years from August 1, 1894, from dusk till midnight in every day, from August 1 till the last day of the succeeding April, except that no public lighting shall be required for three days before and two days after the full moon in each month. In the event of any failure of the lighting of the town, the contractor will forfeit, in each instance, a sum equal to the cost of lighting during the said period of failure calculated at the price set out. The electric company were of opinion that the Commissioners might do well to purchase the electric light installation, spreading the payment over a term of years. The tender of the electric company was considered a very fair one by the majority of the Commissioners. The clerk drew the attention of the Board to the fact that the electric company quoted at so much per annum, and, perhaps, they would make an allowance for the three months that they would not be required to light. Mr. Fullerton and Mr. M'Quillan agreed with the clerk. The clerk then read the tender of the gas company. The majority of the Board were of opinion that it would be well to have a clear understanding with the electric company with regard to their price before deciding in the matter. The question was allowed to lie over till the next meeting.

Lighting of Bandon.—Mr. Wm. Foley moved, and Mr. J. Burke seconded, a resolution, at a meeting last week of the Town Commissioners, to the effect that Mr. T. Scanlan, solicitor, should take steps to oppose the Bandon Electric Lighting Company, Limited, in obtaining a provisional order. Mr. Foley said the promoters of the electric light company were invited to make their case before that Board on three or four occasions, and also before the ratepayers at the public meeting in the Town Hall, but had refused. Mr. Sherlock said he had no doubt that if met in a fair spirit by that Board they (the electric lighting company) would pay off their debentures of £1,700, and the effect of that would be to reduce the town rate. He (Mr. Foley) did not know what was meant by their meeting them in a fair spirit after their repeated invitation to come before them and show how their project could benefit anybody but themselves, except it was that they should hand over to their tender mercy, without question, the interests of the townspeople and ratepayers that they were sent there to preserve. Next year, when they would be under the Towns Improvement Act, they could borrow money for the purpose, and the Board of Trade, they (the Commissioners) being a local authority, would give them the necessary provisional order for the asking. The price charged for the electric light in Killarney was about equal to 5s. per 1,000 cubic feet for gas. There was a further reason why they should not hand over control of the lighting of the town to Messrs. Allman, the promoters of the new company, to be found in the danger there was to the prosperity of small towns of leading firms monopolising everything. In view of the consequences to the town of the hold the promoters of the electric company have over its destinies, it was their (the Commissioners) plain and bounden duty to prevent a single additional twist being given to the vice. It was no wonder that they found amongst the objects for which the electric company was established, one to promote another company to purchase themselves and their liabilities. The resolution was passed.

Lighting at Kensington.—The Highways Committee of the London County Council reported on Tuesday that the Board of Trade has, upon the application of the undertakers, revoked so much of the House-to-House Electric Light Supply Order, 1889, as relates to the area of supply specified in paragraph *h*, of the first schedule to the order, no application for the supply of electricity having been received from occupiers or owners of any premises within the area. The area referred to is situated in the north and north west portion of the parish of Kensington. The same committee reported that they had considered a notice from the House-to-House Electric Light Supply Company of intention to lay mains in Collingham gardens from Bramham gardens to Courtfield-gardens. Both high and low tension mains are proposed to be used, and the committee thought that in the interests of public safety the former should be laid at a lower level than the latter. They therefore recommend that the sanction of the Council be given to the works referred to in the notice upon condition that the company do give two days' notice to the Council's chief engineer before commencing the work; that the mains be laid under the footways wherever it is found practicable to do so, that the low-tension mains be placed 9in. below the underside of the paving, and those of high tension at least a foot lower; that no pipes of larger diameter than 6in. be used; that the street boxes be of the pattern approved by the Council, and that as an additional precaution against accident through defective insulation of the mains, each of the street boxes be provided with an inner as well as an outer cover, the two insulated from each other as far as practicable, and that the outer cover be efficiently connected to earth. The same committee reported that the Kensington and Knightsbridge Electric Lighting Company had submitted for approval a design for service boxes to be placed under the carriageways for use in cases where it is impossible to lay the mains under the pavement. The design appears to be satisfactory except as regards the cover plate, which the committee thought should be somewhat strengthened. They

recommended that the Council approve the design, on condition that provision be made for strengthening the cover-plate to the satisfaction of the Council's engineer.

Lighting at Hampstead.—The Finance Committee of the London County Council on Tuesday reported that they had considered the application from the Hampstead Vestry for the loan of £25,000 for electric lighting purposes. The Vestry proposed to provide a system of electric lighting for the parish, and as a commencement to erect on land belonging to them in the Finchley road the machinery and appliances for an installation for that part of the parish both for public and private purposes. The Vestry had submitted an estimate for the machinery and plant required, which amounted to £19,000 made up as follows: Boilers and accessories, £3,940; pipe work, £1,070; steam engines and dynamos for private lighting, £5,370, and public lighting, £770; switchboards, £720; mains for private lighting, £4,720, and public lighting, £110; arc lamps and posts, £700; and transformer sub-stations, £1,000. It appeared that some of the proposed mains were to be placed in the Finchley road, which is one of the disturnpiked roads, towards the maintenance of which the Council has to contribute, and before interference therewith the Vestry should obtain the sanction of the Council. This has not yet been applied for, but as at present the Vestry required only £5,000 to pay the contractors on account of work done, the committee recommended: "That, subject to the Council hereafter giving its written consent under seal to the borrowing, and subject to all necessary consents and evidence being furnished to the satisfaction of the solicitor of the Council, the application of the Vestry of Hampstead, for a loan of £25,000 towards defraying the cost of providing an electric light installation in the Finchley road for use in the parish, be granted, to the extent of £5,000, on condition that the loan be taken up at once, interest being charged thereon at the rate of £3. 10s. per cent. per annum, payable quarterly on the 1st of January, April, July, and October in each year, and the principal being repaid by equal annual instalments on each 1st October within a period of 30 years; that it be referred to the solicitor to take the necessary measures for completing the loan, and that the amount be advanced out of the Consolidated Loans Fund." The Council adopted this recommendation.

Chelmsford.—The Lighting Committee reported, at a meeting of the Town Council last week, that they had considered an order from the Board of Trade with reference to the placing of electric light wires under ground. They recommended that the wires in High street, Duke street, Tindal street, and King street, as far as the entrance to Messrs. Well's and Perry's timber yard, should be placed underground, but that in the remaining part of King street, Moulsham street, and Anchor-street the order of the Board of Trade as to placing the wires underground should not be enforced. They recommended the Council to accept the offer of the electric lighting company to renew the contract for lighting the public lamps at the expiration of the present contract upon the same terms and conditions as at present existed. The committee further reported that they had considered the provisional order for which the lighting company were applying to the Board of Trade. The order, if granted, would empower Messrs. Crompton and Co. to supply electricity in Chelmsford for 42 years, and to charge for every amount up to 20 units 13s. 4d., and for each unit after 20 units 8d. The committee saw no objection to the order, provided the price charged to consumers was reduced from 8d. to 6½d. for every unit over 20 units, and provided the company gave an undertaking that they would allow a discount of ½d. on every unit over 20 units if the money was paid within a month after delivery, and provided a clause was inserted giving the Council the option of purchasing the undertaking at the end of 21 or 31 years by valuation. The adoption of the report was proposed by Mr. Britton, and seconded by Mr. Osborn. Alderman Chancellor strongly objected to the proposal to give the lighting company the monopoly of supplying the electric light for 42 years. He proposed as an amendment that the matter be referred back to the Lighting Committee for further consideration. Alderman Morton said the provisional order would not prevent the Corporation from erecting plant of their own at any time, or from annulling their contract for the lighting of the town. If the Corporation were bound to have the town lighted by Messrs. Crompton and Co. for 42 years, then it would become a very serious matter for consideration. Alderman Duffield said they were asked upon the mere presentation of a report from a portion of the Council, without their having any opportunity of going into the details of the question or of understanding it, to bind the borough for 42 years. If they did that they would not be acting as sane, business like men. After further discussion, it was agreed that the whole question should be considered in committee by the whole Council. The Town Council have sealed the contract with Mr. T. H. P. Dennis to fix electric fire-alarm calls at the firemen's houses.

Exhibitors at the Smithfield Club Show.—Among the exhibitors at the Cattle Show, which closes to-day, at the Royal Agricultural Hall, Islington, N., are the following: Messrs. Robey and Co. of Lincoln, have on view portable engines, a compound engine and locomotive boiler combined, long stroke horizontal fixed engine, and a high speed vertical engine for electric lighting in mills, factories, etc. This engine is specially suitable where great power is required in a small space. It is designed to work with a high steam pressure, and may be arranged to run at such a speed as may be found most suitable for the work it has to do. When used for electric lighting it is mounted on a cast iron base plate, the other end of which carries the dynamo. The base plate is provided with lugs and adjusting screws, so that the driving-belt can be tightened without stopping the machinery. There are also shown an improved vertical engine, fitted with high-speed equilibrium governor, suitable for driving corn mills and barn machinery, and a Robey horizontal fixed oil engine. This works on the "Otto" cycle, and is mounted on a suitable base plate, containing a chamber capable of holding a week's supply of petroleum for working the engine. The oil used can be the ordinary unrefined heavy petroleum, which is said not to cost more than ¼d. per brake horse power per hour. At the stand of Messrs. W. H. Willcox and Co., of Southwark-street, S.E., is a display of general engineers' stores. There is a collection of best quality hand sewn leather belting, and of patent cork core packing, which is specially adapted for hydraulic purposes. Other exhibits comprise the usual stock packings, viz., self lubricative soapstone, red lead rope for joints, flax and hemp gasket, asbestos in various shapes and sizes, indiarubber valves, sheet, and washers, suction and delivery hose, etc. A speciality is the company's cylinder oil, and a good assortment is also made of general lubricating oils. There is shown for the first time the Penberthy patent injector. This obtained a medal at the Chicago Exhibition. The Farringdon patent pump is also on view, and a good general display is made of engineers' sundries, such as cotton waste, steam engine fittings and boiler mountings, lubricators, gauge glasses, screwing tackle, portable forges, grindstones, etc. The Britannia Company, of London and Colchester, show a 3 h.p. petroleum engine of the Roots type, for which they have acquired the sole right of manufacturing. This engine is operated by common petroleum lamp oil, and it is claimed that it is specially adapted for pumping and electric light purposes. There are also to be found at this stand a single geared milling machine for the use of engineers, brass finishers, etc., and a powerful shaping machine. Several types of gas engines, exhibited by other firms, are shown in operation, some of them driving dynamos for arc and incandescent lighting.

Lighting of Dewsbury.—The work of laying the mains is being executed by Messrs. Siemens Bros. and Co., who are carrying it out under contract with the Corporation. The Corporation took in the early stages of the project the advice of Mr. W. H. Preece, and the system about to be adopted is one he recommended. The electricity works will occupy the site of the old gasworks in Bradford road. The committee, which has the management of the gasworks as well as of the electric lighting scheme, is composed of the following gentlemen with the Mayor (Alderman Pyrah ex-officio, Alderman Robinson (chairman), and Councillors Archer (vice-chairman), Birkhead, Bullock, Fox, Howroyd, Knowles, and Whiteley. The amount of tenders for the complete scheme of lighting varied, the lowest being £14,636 (alternating currents), and the highest £25,050 (continuous current). The tenders were referred to Mr. Preece, who recommended the following to be accepted: Messrs. J. and H. Horsfield, Dewsbury, boilers, with an addition of £102 for pipe works, £3,000. Messrs. Crompton, steam pipes £758, condensers £1,176, steam dynamos £4,364, and switchboards £415, with a reduction of 5 per cent., £6,378; also arc lamps and posts, less the same discount, £983, and batteries £996, or a total of £8,357. Messrs. Siemens and Co., mains, including arc mains, £3,750, making a grand total of £15,107, which, however, will be reduced by £2,500 if arc lighting be excluded for the present, or a net figure of £12,607 to be expended, exclusive, of course, of engine and boiler houses. The engines to be supplied by Messrs. Crompton are of the Willans type. The mains have just been laid down in various streets and thoroughfares. The mains are on the three wire system. All this work of laying mains, etc., under Messrs. Siemens's contract is being carried out under the direction of Mr. Greene, their local manager. As to the engine and boiler houses, the first will be erected on the site in Bradford road in such a manner that extensions can be easily and economically carried out. The Corporation have issued a circular to the inhabitants in which it is stated that: "An 8 c.p. electric incandescent lamp may be taken as equivalent in lighting power to an ordinary gas burner of the usual size—that is, one consuming four cubic feet of gas per hour. Electricity will be sold at 6d. per unit; the cost of an 8 c.p. lamp is rather less than one farthing per hour. In London it is found that the average number of hours per annum during which an 8 c.p. lamp burns is under 300 hours. With electricity at 6d. per unit the average cost per 8 c.p. lamp is about 6s. 6d. per annum, including incandescent lamp renewals. The cost of wiring and fittings depends on the premises wired, the number of lamps installed, and the individual taste of the consumer. It may be taken as varying from 25s. to 35s. per lamp for shops, offices, etc., and from 30s. to 50s. per lamp for private houses."

Lighting of Swansea.—A Welsh paper, writing about the electric lighting of this town, says: "The Swansea Corporation is in possession of full powers—monopolistic powers—for the lighting of the borough with electricity. It will not be prudent for the Corporation to allow these powers to pass out of the hands of the municipality into the hands of any private individual or company, as was done long ago in the case of gas and gas lighting. Already a company has applied to the Board of Trade for a concession to them of the electric lighting powers of the Swansea Corporation, on the ground that the Corporation does not now make use of its powers practically. It is understood that other company promoters have similar intents upon the borough and upon its electric lighting powers. The fact that one company has thus applied to the Board of Trade will necessitate some clear and consistent declaration on the part of the Swansea Corporation as to whether it does, or does not, intend supplying the borough with the electric light. The Corporation has already declared that it will reserve to itself the power it possesses, and, in order to rebut the proposal of the above

commercial company, the Corporation will have to go before the Board of Trade and make good its own position. So far so good. We shall await with interest the issue of this important case. Meanwhile, the members of the Corporation and the burgesses as a whole have to face, and ought to face wisely and with foresight, the problems of the immediate future. It would seem to be too hazardous, as well as too big a venture for the Corporation at present to undertake the installation of electric lighting for the community. No doubt there are some other things that would work in with it, and be auxiliary to it, when this great determination shall have been arrived at. We shall want a mechanical destructor for the refuse of the community; and it is roughly estimated that such a destructor may easily be made the means of affording continuous mechanical power to the extent, say, of 40 h.p., day and night, at little cost. This 40 h.p., it is assumed, might be utilised as an instalment of the power necessary for the creation of electric light. These, however, are matters for further enquiry and clearing up. Meanwhile, the Corporation might, if opportunity properly offers, hand over its electric lighting powers, temporarily, but only temporarily, to a private company, under the most careful conditions and restrictions. The world is anxiously waiting for the discovery of some cheaper means or method than now exist for the creation of the force used in electrical illumination. As soon as this discovery is made, the electric light may be far cheaper, and far easier to work, than gas making and gas lighting, and thus the possession of monopolistic powers in the municipality will be a most valuable possession, which we, in our own day, or our successors soon after us, ought to enjoy the benefit and profit of."

Lighting at Dover.—A large number of gentlemen, interested as business men and inhabitants of Dover, assembled in the Council chamber in the Town Hall last week, at the invitation of the Brush Electrical Engineering Company, to hear an explanation with reference to the objects of the Dover Electricity Supply Company, Limited. The chair was taken by the Mayor of Dover (Sir W. H. Crundall, J.P.), who is the chairman of the new company, supported by Mr C. W. Bagshaw (vice-chairman and director), Mr. Sellon (director of the Brush Company), Mr Lawson (engineer of the Brush Company) and Mr W. Mowll (solicitor to the Dover Company). The Chairman introduced his brother directors, Messrs. Bagshaw and Sellon, Mr B. H. Van Tromp not being able to be present. He congratulated the company on receiving such a large amount of support. He reminded them that by a recent Act of Parliament the Corporation of Dover were given the opportunity of obtaining a concession for supplying electricity to the town. They did not see their way to enter into the business themselves, but they obtained the concession by means of a provisional order, with a view to transferring that concession to a company who would satisfy them that they had sufficient capital to instal the light in a proper manner, so that they would control it and see it started on the right lines. After a year or two of discussion the Corporation transferred the order to the Brush Company for a consideration, the Brush Company in their turn undertaking to form a local company. It had gone so far that the local company had been registered in the usual way and the board of directors formed with two representatives of the Brush Company and Mr. Bagshaw and himself as local directors. They hoped by next August or September that the tradesmen and residents of Dover would have the opportunity of supplying themselves with electric light, and they had also entered into a contract with the Corporation by which the sea front and one of the main streets would be lighted, with power to extend if they thought fit. Mr Sellon said the question of electrical lighting ought to be looked at from two points of view. First, that of the consumer, and secondly, that of the investor. These two points differed in some degree. The consumer wishes to be sure that it would be reliable, economical, and safe as regards life and property; and the investor wanted to know, over and above all, whether it was going to pay. As regards the question of cost, the speaker said that on an average it would cost from £1 to £1 5s. per light for the entire cost of fitting up. As to the cost of the illuminant, Mr Sellon said he found that from personal experience of the light in his own house for the past two or three years, it was from 20 to 30 per cent. higher than that of gas. But in spite of that, the greater advantage as regards health and convenience and preservation of furniture led to its adoption on an enormous scale. Alluding to the general position in Dover, he said that the company would commence operations in the course of the next month, and by July next there would be a station capable of supplying 5,000 incandescent lights, and they hoped to be able to supply 10,000 incandescent lights in 1895, and that they would be further enabled to extend this, as the company would have capital enough to be good for 20,000 lights. They estimated that the receipts would allow of a dividend of something between 7 and 8 per cent. Several questions were then asked and answered. It was stated that the street lights would be arc lights of 3,000 c.p., and that arc lights of 1,000 c.p. or less could be supplied for business purposes. The high tension system would be used for the mains in the street, but only low tension currents would be introduced into houses.

Lighting at Taunton.—The Electric Light Committee of the Town Council have considered Dr. Fleming's recommendations with regard to the extension of the electric lighting. The committee reported at a meeting last week that Dr Fleming states that it will be necessary at once to commence laying some of the underground lines. He proposes to get rid of the small house transformers, and to supply the central portion of the town from one common set of transformers, to be placed in sub-stations. The committee have had the cellar under the Municipal Buildings fitted up in order that it may be used as a sub-station for district No. 1, and they propose to lay a high tension cable from the electric light works to this cellar, in which will be placed two 30 kilowatt transformers and switches, and from there will be laid an underground three wire secondary cable, extending in each direction for 220 yards on both sides of the way down North-street, High-street, Fore-street, and East-street. The committee have obtained tenders (which have been submitted to Dr Fleming and upon which he reports) for a small alternator and exciter of 25,000 watts capacity, two 30 kilowatt (40 h.p.) transformers and switches, a quarter of a mile of high-tension cable, one mile of secondary distributing main, and a small high-speed engine for driving the small alternator. The committee recommended that the following tenders be accepted: Messrs. Laing, Wharton, and Down, for a small alternator and exciter, £284, and two 30 kilowatt transformers and switches, £261. 16s.; Messrs. Bunsted and Chandler, for a small high-speed 50 h.p. engine, £343; the British Insulated Wire Company, for a quarter-mile length armoured concentric cable, £81 5s.; and that the tender of the Fowler Waring Company for about one mile of triple concentric distribution cable be accepted, provided they will supply the exact length required at 7s. 4½d. per yard, and that an arrangement can be made with them to joint on all customers as required, lay and joint in the feeding mains, and generally to complete all the work in the first district, except opening and closing the ground; also to guarantee all the cable for five years, making good at their own expense all failures in ordinary work in that time. Councillor Potter, in moving the adoption of the report, said that one of the causes for the late electric light company's undertaking proving so disastrous was that at no time was the machinery employed at its full capacity. It was somewhat different now, as there were 1,250 lamps as compared with 486 previously, but that was not a continuous number. The number of lamps in use varied, some being used in the afternoon. All the tenders had been sent to Dr. Fleming for his approval, and the recommendations made by him were the recommendations of the committee, so that the report the committee now made was really not so much their own recommendation as it was of Dr. Fleming. Councillor Hammett seconded the motion. Some discussion then took place in regard to the great differences in the amounts of the tenders. It was ultimately decided to take the tenders *seriatim*. The first tender was accepted. With regard to the second tender Alderman Standfast moved that Messrs. Newton's tender be accepted, and one or two members present supported the idea, remarking that they thought the money should be spent in the town as much as possible. Councillor Potter mentioned that the tender of Messrs. Johnson and Phillips, which was the next one in price and the alternative one recommended by Dr. Fleming, was considerably lower than Messrs. Newton's tender, which he did not even mention. It was decided that providing Messrs. Newton could satisfy Dr. Fleming as to their instrument their tender should be accepted, and if not that of Laing, Wharton, and Co. should be accepted. The rest of the tenders were accepted, and the proceedings terminated.

Lighting in the City.—When the City Commissioners of Sewers met on Tuesday, Mr Burmester moved a resolution to the effect that the gas standards should be removed from the streets now lighted by electricity, and that the Streets Committee should carry this out. He said this was the legitimate outcome of the report of the engineer on electric lighting, which practically was to the effect that the electric lighting was satisfactory. The engineer reported that the majority of failures were not in groups, or for long periods of time, and that the total percentage of time the lamps failed was small. The electric light company thought the engineer ought in justice to have stated the actual percentages of failure, and they had supplied figures to the effect that the total number of hours during which the lamps were burning was 783,343, while the total number of lamp hours failure was only 374. The percentage of failure in lamp hours was thus ·047, or what was equivalent to one hour's failure in every 1,230 hours. He thought that justice ought to be done to the company by giving them credit for the way in which they had lighted the streets. The total amount of gas consumed on account of the failure of the electric light during the six months had cost the Commission 1s. 2d., whereas the engineer reported that the Commission were paying for maintenance of the gas lamps at the rate of £1,182 per annum. He thought the Commission would hardly consider it worth while continuing to pay this amount in order to burn gas to the extent of 2s. 4d. worth a year, to say nothing of the extreme inconvenience caused by the unused gas standards. After some discussion this motion was adopted. The question as to delays in the supply of current to private consumers was next considered. Mr Smallman submitted that a number of his neighbours were complaining that they had had their electric light fittings for some considerable time, but they had not yet had the current supplied. He asked whether there was no way by which the company could be stirred up to do their duty in this respect. The Chairman said that he had sent a letter he had received from one of his constituents on the subject to the electric light company, and he had received a reply from Mr. J. Cecil Budd, the secretary to the company. Mr Budd stated that the company were most anxious to supply all consumers and to avoid delay. As regards the preparations made at a great cost months ago by various firms, he could sympathise with them, but it must be borne in mind that this company never asked them to make such early preparations, nor have ever made promises to give them the light by a definite date. Continuing, Mr. Budd said: "They have to thank the irresponsible wiring contractors, with whom this company has no connection whatever, and who made all sorts of rash promises without authority in order to obtain the work. Now, as to the cause of the alleged delay. It must first be

borne in mind that we are a supply company, and cannot manufacture our own plant any more than the Commissioners can, but in order to prevent delay as much as possible, we have done everything that we can do ourselves, such as all building work, street work, etc. Then, again, our aim has always been to obtain the very best plant and cables. Sufficient generating plant has now been erected at Bankside to meet the demands of all applications for current lodged with us, and further machinery is being daily erected. When we come to the distribution plant, however, the contractors have not kept faith with us, and transformer equipment ordered by us over a year ago is not yet delivered The contractors allege all sorts of excuses for this strikes, non-delivery of proper raw material, and so on. Unfortunately, the equipments are as a rule patent articles, obtainable except from only certain firms We have now, however, made such arrangements as will overcome the transformer difficulty. You will also remember that it was only comparatively recently that we obtained sites for the 22 transformer stations of the area in which Mr. Ettlinger is situated viz., Milk street area was one of the last. As regards cabling, we are now drawing in cables at the rate of between five and six miles a week. While on this point, I do not think that it is understood by the Commissioners that the system of distribution we have adopted in the City is the latest and best - viz., with central transformer stations instead of small transformers in each house. This however, prevents us from supplying individual consumers dotted about in various parts of the City, as they seem to imagine can be done. Each transformer area must be complete in itself, and include all its own consumers. Naturally, we complete the areas in which there are most consumers, first leaving those in which there are but few to follow in rotation. Mr. Ettlinger's area is one of the latter, and I generally find that those people who are situated in an area in which there is least demand make the most fuss. As far as we possibly can, we are also putting in meters and house service boxes, and getting things generally all ready for joining up. The next areas we are dealing with are Lime street square, Rood lane, Warwick square, and Coleman street, and the others will be taken in order of number of applications, but, as far as I can see, all (except the outlying areas like the St. James's square, Redcross street, and Fetter lane ones) will be completed at different dates within, say, two months. The areas vary in size but an average area takes about 10 miles of cable. Some little delay takes place in joining the cables, as good jointers are scarce, and as it is one of the most important operations in the company's work, it would not be safe to employ other than fully-skilled workmen. It must not be forgotten that we are already supplying over 60,000 lamps, and have completed services ready to join up nearly 15,000 more. In conclusion, I must say I do not think the Commissioners fully appreciate the magnitude of the undertaking. We have expended over £700,000, and this should give a good idea of the amount of work which has been already carried out. I can assure you and the Commissioners that we are straining every nerve to make the private lighting of the City a success from every point."

PROVISIONAL PATENTS, 1893.

NOVEMBER 27.

22698. **Detector galvanometers.** William Routledge, 46, Low Friar street, Newcastle-on-Tyne.

22723. **Improvements in telephonic transmitters** Guillaume Arnaud Nussbaum 29, Ludgate hill, London.

NOVEMBER 28.

22765. **Multiple telegraphy** Jeremiah McCrath, The Elms, Melton Mowbray. (Complete specification.)

22817. **Improvements in electric meters** Hermann Aron, 6, Lord street, Liverpool

22856. **Improvements in printing telegraphs.** Robert Ashworth Fowden, Norfolk House, Norfolk street, London

22858. **Improvements in electric lighting and extinguishing apparatus for gas burners** Erik Orling, 45, Southampton buildings Chancery lane, London. (Complete specification.)

22863. **Improvements in and relating to dynamo-electric machines** Henry Harris Lake, 45, Southampton buildings Chancery lane, London (The Thomson Houston International Electric Company, United States. (Complete specification.)

NOVEMBER 29.

22885. **Improvements in and connected with electric generators and motors.** Montague Tabor Pickstone, 2, Todd street, Higher Broughton, Salford.

22912. **Improvements in electrodes and cells for secondary batteries or accumulators.** Edward Henry Wheeler, Walton-road, East Molesey, Surrey.

22956. **New improved electro-positive galvanic battery electrodes.** Carl Anton Johannes Hugo Schroeder and Heinrich Eugen Richard Schroeder, Whetstone House, Heslop-road, Balham, London. (Complete specification.)

22957. **Improvements in arc lamps** John Henry Wheat and Arthur Wheat, 323, High Holborn, London

22960. **Improvements in or relating to the method and means employed for controlling electrical devices from a distance.** Henry Wall Wilkinson and Leonard Penson, 433, Strand, London.

22959. **Improvements in or relating to apparatus for controlling transformers used in feeding electric current circuits.** Henry Wall Wilkinson, 433, Strand, London.

NOVEMBER 30.

23017. **An improved arc lamp.** Henry Robert Low and Frank Robert Brown, 1, Castle yard, Richmond. (Complete specification.)

23022. **Improvements in or relating to junction service boxes for electric conductors.** George Hinde Nisbett and James Bassnett Atherton, 6, Lord street, Liverpool.

DECEMBER 1.

23074. **Improvements in electrical switches.** William Paul Thoermann, 11, Great Ducie-street, Strangeways, Manchester.

23083. **Improvements in apparatus for recording electric currents** Hermann Aron, 6, Lord street, Liverpool.

23088. **An improved electrical indicating target.** George Henry Hodges and James William Ireland Hilliard, 4, St. Faith's villas, Fullerton road, Wandsworth.

23107. **Improved electrical games or toys.** Alfred Crespin and Oscar Felix Lehmann, 23, Southampton-buildings, Chancery-lane, London.

23116. **Improvements in electrical apparatus for indicating or indicating and registering variations in temperature or pressure or both.** Leo Sunderland, 46, Lincoln's inn-fields, London

23121. **Improvements in incandescence electric lamps.** James Yate Johnson, 47, Lincoln's inn fields, London. (Charles Henry Stearn, Switzerland.)

DECEMBER 2.

23133. **Improvements in electrical cranes or travellers** Henry James Coles, 89, Sumner street, Southwark, London.

23170. **Improvements in electrical transformers.** Leslie Bradley Miller and Maurice Walter Woods, 2, Gray's-inn road, London.

23182. **Electric station-indicator for railway waiting-rooms.** Adolf Jeenel 38, Alexandra-strasse, Berlin, Germany.

23211. **Improvements in electro-mechanical governors, and in the means of operating the same** Walter Thomas Goolden and Joseph Slater Lewis, 1, Queen Victoria street, London.

23221. **Improvements in sockets or receptacles and regulators for incandescent electric lamps.** Henry Harris Lake 45, Southampton buildings Chancery lane, London (Charles Albert Hussey and Charles Coulthurst Edey, United States.)

SPECIFICATIONS PUBLISHED.

1885.

5627. **Electric tramways and railways.** Smith. (Second edition.)

1890.

6083. **Electric propulsion of tramcars.** Gordon. (Second edition.)

6236. **Storage battery.** Jarman. (Second edition.)

1892.

18165. **Telephonic apparatus.** Lake (Noriega.)

21147. **Electric vehicles** Garrard and Blumfield

21693 **Electrical meter and recorder.** Feys and Lorwe.

22271. **Electric arc lamps.** Haseltine.

1893

257. **Insulating electric wires** Crompton and Dowsing.

5084. **Fastening electrical conductors, wires cables, etc.** Day.

8176. **Electrolytic apparatus** Hanbury.

10765. **Secondary batteries** Clubbe and Southey.

18894. **Standards of electromotive force.** Muirhead and Dearlove

18945. **Telephonic transmitter circuits.** Brookes. (Cousens.)

19024. **Trolley supports for electric railways.** Andersen.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3
— Pref.	—	2¾
Charing Cross and Strand	—	5
City of London	—	11¼
— Pref.	—	13
Electric Construction	—	1¾
House to House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22¼
Liverpool Electric Supply	5	6¾
	3½	4¾
London Electric Supply	3	1
Metropolitan Electric Supply	—	7¾
National Telephone	5	4¾
St. James, Pref.	—	8½
Swan United	3½	3¼
Westminster Electric	—	5¼

NOTES.

Paris.—Extensions are being made in the municipal electric lighting district.

The Late Prof. Tyndall.—The body of the late professor was interred on Saturday at Haslemere.

Search-Lights.—A search-light has been arranged on the roof of Princess's Theatre, Oxford-street, by Mr. R. A. Scott.

Brixton.—A series of lectures on electricity is to be commenced at St. John's Institute, or Eltham House, Brixton, at the beginning of the new year.

Junior Engineering Society.—The members of this society on Friday last passed a vote of condolence with Mrs. Tyndall in connection with her recent bereavement.

Flexible Metallic Tubing.—It has hitherto only been possible to manufacture flexible metallic tubing up to 3in. diameter. Now, however, this kind of tubing is being produced up to 8in. diameter.

Lea Bridge Tramways.—The Lea Bridge, Leyton, and Walthamstow Tramways Company, who are asking for subscriptions for unissued capital, have powers to introduce electric or other power on their lines.

The Leeds Tramways.—A sub-committee of the Corporation Highways Committee has been appointed to deal with the whole question of the Leeds tramways, the transference of which from the present company is expected to take place shortly.

Engineers and Shipbuilders.—The third ordinary meeting of the North-East Coast Institution of Engineers and Shipbuilders will be held in the lecture-hall of the Subscription Literary Society, Fawcett-street, Sunderland, on Wednesday next at 7.40 p.m.

They Disliked the Bogies.—Some of the inhabitants of Brixton have complained of the noise made by the cable cars. Major-General Hutchinson is to report to the Board of Trade as to whether or not a further license is to be granted to the tramway company.

A Retrogressive Step.—The high price of gas due to the coal strike has caused the public lighting inspectors of Crowland, Lincolnshire, to decide to light the streets with oil instead of with gas. Why not make a forward step and introduce the electric light?

Shiplighting.—The "Forte," which was launched at Chatham Dockyard on Saturday, is a steel-protected, wood-sheathed, twin-screw, second-class cruiser. She will be fitted with three search-light projectors, and will be lighted by incandescent lamps, two dynamos being arranged in the engine-room.

Longton.—The Town Council have appointed a sub-committee to ascertain the powers of the Council as to the completion and working of the tramways in the borough, to make enquiries as to what is being done in other towns where tramways exist, and also to enquire as to the best method of traction.

Traction at Newcastle.—A scheme is under consideration for the adoption of cable trams in this town. A local paper discussed the question a few days ago, and compared the cost of working of the different systems of haulage introduced on the lines of the Birmingham Central Tramways Company.

New Method of Signalling.—A new system of signalling by day or night, designed for the use of the naval, military, merchant-marine, lighthouse, and life-saving services will be described at the Royal Service Institution to-day by Colonel Gouraud. A practical demonstration of the application of the system will be given.

The Devil's Dyke.—We note that the Cliff and Aerial Railway, Limited, has been registered with a capital of £20,000 in £1 shares, to construct and maintain an aerial flight or railway across the Dyke at Brighton. This matter was referred to in a previous issue, when, it will be remembered, it was mentioned that electricity will be used for motive-power purposes.

Conversazione.—The annual conversazione of the National Telephone Company took place in Glasgow the other day. It appears that the subscribers in the Scotch district of the company number 10,167, being an increase of 1,143 over the previous year. The mileage of the company in the district is 14,800, being an increase of 1,500 miles over the previous year.

The Government and Telephony.—The *Pall Mall Gazette* learns that there is no prospect of the agreement between the Post Office and the National Telephone Company being laid on the table of the House of Commons this session. Mr. Arnold Morley promised it some time in the autumn session, but it has not made its appearance, nor is it likely to do so before the House adjourns.

The Society of Engineers.—The fortieth annual general meeting was held on the 11th inst. at 17, Victoria-street, S.W. The chair was occupied by Mr. William Andrew McIntosh Valon, J.P., president. Mr. George Abraham Goodwin was elected president for 1894. The annual dinner was given at the Holborn Restaurant on Wednesday, the president, Mr. W. A. McIntosh Valon, J.P., occuping the chair.

The Liverpool Railway.—In the House of Commons last week Mr. Snape asked the Secretary to the Treasury whether the overhead electric railway at Liverpool had been assessed to the passenger duty; and, if so, on what terms. In reply, Sir J. Hibbert stated that no assessment had yet been made, and that the Board of Inland Revenue were in correspondence with the company on the subject with the view of determining the terms of charge.

The "Medical Battery" Company, Limited.—The official receiver has been appointed liquidator of this Company. Mr. Hannay resumed on Wednesday the hearing of the charges of conspiracy to defraud brought against Messrs. C. B. Harness, J. M. McCully, C. B. Hollier, and D. Towers. Mr. Thomas Terrell, one of the barristers for the prosecution, mentioned that he had about 400 witnesses to call. The hearing was again adjourned for a week.

The Joule Memorial Statue.—Lord Kelvin, last week, unveiled the Joule memorial statue, which has been placed in the Manchester Town Hall as a gift to the city. The work has been done by Mr. Albert Gilbert, and the statue forms a not unworthy companion to Chantrey's statue of Dr. Dalton, of whom Joule was, in his early days, a pupil. In an address delivered at the time, Lord Kelvin dealt with the discoveries and experiments of Joule.

Accumulator Works.—The Departmental Committee appointed by Mr. Asquith to enquire into white lead and the allied industries have issued their report. In regard to electric accumulator works, the committee recommend the adoption of respirators and overalls for mixers; the provision of gloves and aprons for rubbers; the provision of bath and lavatory accommodation, with a plentiful supply of hot and cold water, soap, nail-brushes, and towels.

Chesterfield and Midland Engineers.—A general meeting of the Chesterfield and Midland Counties Institu-

tion of Engineers will be held in University College, Nottingham, to-morrow (Saturday), at 2.30 p.m., when various papers will be open to discussion. The following papers will be read or taken as read: "The Hydrogen Oil Gas-testing Safety Lamp," by Prof. Frank Clowes, D.Sc.; "Automatic Expansion Gear in Use at Blackwell Colliery," by Mr. Maurice Deacon.

Royal Meteorological Society.—An ordinary meeting of this society will be held at 25, Great George-street, Westminster, on Wednesday next, at 8 p.m. Papers on the following subjects will be read: "The Great Storm of November 16th to 20th, 1893," by Mr. Charles Harding, F.R.Met.Soc.; "Rainfall and Evaporation Observations at the Bombay Waterworks," by Mr. S. Tomlinson, M.I.C.E., F.R.Met.Soc.; and "On Changes in the Character of certain Months," by Mr. A. E. Watson, B.A., F.R.Met.Soc.

Electric Lighting in Dublin.—The Postmaster-General was interrogated on Monday by Mr. Henniker Heaton as to whether he had entered into agreement with the Municipal Corporation of Dublin for the supply by them of the electric light to the General Post Office, Dublin. In reply, Mr. A. Morley stated that no such proposal was under consideration. Perhaps, he observed, the question referred to the new parcel sorting office in Amiens-street, where the Board of Public Works were proposing to provide the electric light.

Chamber of Arbitration.—The revision of the list of arbitrators for the Chamber of Arbitration of the London Chamber of Commerce is now in progress. The list already comprises the names of 1,400 gentlemen engaged in over 100 different professions, branches of trade, industry, etc., who have consented to act if selected by parties to references. Opportunity is now provided to add to the list. The following clause is recommended for insertion in contracts and agreements: "All disputes which may arise shall be submitted to arbitration under the rules for the time being of the London Chamber of Arbitration."

Risks (?) of Overhead Wires.—Minneapolis can hardly be called an unimportant city of the United States, and yet overhead trolley wires are there employed for tramways through the business parts of the town. The only accidents (or incidents) that have resulted since January 1, 1891, to date, have been—on the authority of the city inspector—three fires, with no damage resulting; four horses killed, and one man's leg broken owing to his fall from a pole on which he had received a slight shock. Taking into account the notoriously rough-and-ready way in which overhead construction is carried out in America, and the higher voltages there employed, there seems no reason why we need greatly fear the introduction of trolley wires in this country.

Electrical Communication with Lightships.—Mr. James Lowther asked the President of the Board of Trade in the House of Commons last week what actual progress had been made towards carrying out the recommendations of the Royal Commission with regard to electrical communication with lightships. In reply, Mr. Mundella observed that he replied to that question in answer to the hon. member for Dundee the previous week. He then stated that the work of connecting with the shore by electric cable the North Goodwin and the Kentish Knock light-vessels was being proceeded with as rapidly as practicable, and he hoped they would be completed during the present financial year. On Tuesday, Mr. T. W. Russell asked the President of the Board of Trade whether he would lay upon the table a return giving the correspondence between shipowners, Chambers of Commerce, Mr. T. R. Wigham, members of Parliament, the Commissioners of Irish Lights, the Trinity House, the Board of Trade, and others on the subject of lighthouse illuminants which had taken place since the issue of the last return on the subject. In reply, Mr. Mundella said that the correspondence was published up to February 24, 1893, and that which had ensued had not been such as to justify the cost incident on the printing and presentation to Parliament.

New South Wales Electric Club.—We have received a copy of the report of this club for the year ending September last. The council congratulate the members upon the success which the club has attained. Whilst the year has been a satisfactory one as regards the work of the club, the council regret to record losses of some of their most valued members by death. The council also regret to have to report a number of resignations, chiefly on account of members leaving the colony, but there is reason to believe that their loss will be made up by the accession of new members during the ensuing year. During the year 14 general meetings have been held, and papers on the following subjects were read and discussed: By Mr. P. B. Elwell, on "The Application of Secondary Batteries to Electric Traction"; by Mr. O. Haes, on "The Lighting of Railway Trains"; by Mr. O. W. Brain, on "Electricity as Applied to Mining"; by Mr. E. R. Dymond, on "Fire Insurance Rules as Applied to Electricity"; by Mr. A. F. Williamson, on "Central Stations"; by Mr. H. H. Kingsbury, on "Thirteen Years' Electrical Progress of New South Wales"; and, in addition, a discussion took place on "The Draft Code of Rules and Regulations for the Erection of Overhead Electric Light and Power Wires." The club were also invited to attend a paper read by Prof. Threlfall on "Some Problems Occurring in the Construction of Electromagnetic Reciprocating Mechanisms," before the Royal Society; also by Mr. T. D. Richards, on "Electricity as a Fire Risk," before the Insurance Institute of New South Wales.

The Pacific Cable Question.—We quote the following from the *Canadian Gazette*: "Mr. Sandford Fleming cannot fail to be encouraged by the reception given in the Australian colonies to his advocacy of a British cable across the Pacific. Queensland was, it will be remembered, one of the colonies to subsidise the French cable to New Caledonia; but, if we may believe Sir Thomas McIlwraith, until quite recently premier of the colony, this step was only taken in despair of getting a wholly British line. Speaking at the reception tendered to Messrs. Bowell and Fleming, Sir Thomas declared that he had always held that Australia ought to have subsidised a direct cable line to Canada, and that it should be done by the colonies interested at a price that would defy competition. Mr. Fleming would, he declared, have all possible help. All he desired was direct communication with Canada, and if it could be carried out by British capital, so much the better. Sir George Dibbs, the premier of New South Wales, the other colony which came to the help of the French company, gave Mr. Bowell equally emphatic assurances of sympathy. The New Caledonian line would, he hoped, wake up the British Government to the necessity of constructing a separate cable to Vancouver *viâ* New Zealand, Fiji, Samoa, and Honolulu; and he failed to see that the French cable should banish the demand for assistance in laying any such future Pacific cable through British possessions. The Intercolonial Conference which will, it is hoped, be convened at Ottawa about the middle of June next, and include representatives of all the Australasian colonies, will, we may hope, put these assurances of sympathy to a practical test."

The City Telephone Tubes.—The City Commissioners of Sewers had submitted to them last week a letter

from the City of London Electric Lighting Company asking the Commission to terminate the existing deadlock as to the telephone tube question by giving their consent as required by the Telegraph Act, 1891. The company first controvert the assertion that the tubes were laid simultaneously with the electric lighting mains without the knowledge of the Commission. With reference to the conditions which the Commission sought to impose on the users of the tubes—to grant a telephone service within the City at £8 per annum—the company were informed by the highest authorities that that was incompatible with an adequate return on the capital invested. No company had an exclusive right to supply telephone service in any part of the kingdom, for the Post Office authorities had repeatedly expressed their willingness to open exchanges if a certain number of subscribers asked them to do so, and, as they could carry out such a service more cheaply than a private company, any risk of a monopoly at once vanished. The existence of that powerful check against exorbitant charges would seem to render unnecessary a resort to exceptional measures. The company was erecting plant, etc., to supply 25,000 customers with electric light. If the revenue derived from telephone tubes be reduced to please 3,000 citizens, it could only be, it was submitted, at the expense of 25,000. In the meantime the tubes were lying idle, neither benefiting electric light users nor telephone subscribers. The existing companies, it was said, were every day putting numerous wires overhead which might, in many cases, be placed underground. The letter of the company is now under the consideration of the Commission.

A One-Volt Standard Cell.—In the *American Journal of Science*, Mr. H. S. Carhart considers this subject. The author employs a one-volt standard cell of the same form as the Clark standard. The tube contains pure mercury in contact with a platinum wire; on this is placed mercurous chloride paste, covered with zinc chloride solution. A cork diaphragm, with asbestos packing under it, is employed to keep the paste in position, and above it is placed more zinc chloride solution containing an amalgamated zinc rod; the whole is then hermetically sealed. The specific gravity of the zinc chloride solution necessary to give an E.M.F. of one volt at 13·7deg. is 1·391 at 15deg. The internal resistance of the cell is about 1,500 ohms, and it seems to suffer no permanent change by heating at 50deg. It is noteworthy that this cell has a positive and very small temperature coefficient; from 10deg. to 40deg. the temperature curve is approximately a straight line, and the E.M.F. is obtained from the equation, $E_t = 1 + 0{\cdot}000094\ (t - 15)$. Above 40deg. the curve rises and involves the third power of $t - 15$. The E.M.F. is observed to lag somewhat as the temperature falls; the hysteresis is, however, very slight, being equivalent to about 3deg. difference of temperature. The sign of the temperature coefficient of standard cells depends on the relative magnitudes and signs of the thermo E.M.F.'s at the two sides of the couple. These may be experimentally determined by means of an H-tube containing the solution and electrodes of the metal concerned, one limb of the tube is kept in melting ice, and the other in a bath at the required temperature. The E.M.F. set up is determined electrostatically, and is balanced against a standard E.M.F. Employing this method, the author has measured the thermo-E.M.F. of the voltaic series $Cu \mid CuSO_4, Cu$ between 0deg. and 50deg. as + 0·00073 volt, and has hence calculated the values for several other series, and compared them with the experimental values. The data given by Bouty, and by Chroustchoff and Sitnikoff (*Compt. Rend.*, 108, 937), would show the temperature coefficient of the author's cell to be small but negative. Bouty's thermo-E.M.F. for the series $Zn \mid ZnCl_2 \mid Zn$ is, however, too large; the author finds it to be 0·000584, a number from which the temperature coefficient of the new cell is calculated as practically identical with the value obtained experimentally.

The Board of Trade Draft Rules for Electric Traction.—In the short interval that has elapsed since the above regulations were issued by the Board of Trade for criticism by electrical experts, considerable progress has been made by the interests more particularly concerned with a view to undertaking not only individual but united action also, in the hope of effecting such changes in the rules, as drafted, that the reasonable development of electric traction shall be helped and not hindered. It is expected that the Institution of Electrical Engineers will set aside one of its ordinary meetings for discussing these regulations and the problems they involve; though, of course, no arrangements of this kind can now be made before the New Year. Yesterday afternoon the Municipal Associations formally began their criticism of the rules at a meeting of their delegates and officers to discuss this matter and decide upon some course of action. Finally, the third group of interests deeply concerned in the question—the Electrical Trades Section of the London Chamber of Commerce—instituted a similar movement on Friday last, when a sub-committee of well-known and influential men assembled to deal with the rules as might seem best to them. Amongst those present were Messrs. Crompton, Garcke, Stephen Sellon, R. P. Sellon, H. F. Kite, Carruthers Wain, etc.—all intimately connected with the electrical and traction interests—and a considerable amount of important business was transacted. After deciding upon an immediate course of action, the rules were discussed *seriatim*, and no lack of criticism resulted. On many points it was settled that further information should be sought from the Board of Trade, inasmuch as the rules were in a number of instances excessively obscure. The whole of Rule 6, with its sub-divisions, was referred to a special sub-committee in order to work out and compare the practical results which would follow if, in the first place, the rule were finally approved as it is, and, secondly, if it be amended in any one of several advantageous ways. Sub-section *a* of this rule is probably the most vague in the whole set; for a "separation" of the uninsulated return from earth can only mean that it shall be insulated, an obvious absurdity. Rule 14 is regarded as absolutely traversing the entire conclusions of the joint parliamentary committee, and if it be allowed to stand must inevitably postpone the development of electric traction to any extent whatever. It should be expunged altogether, as also should Rules 15 and 17, which are not only unnecessary but simply impossible to carry into effect. Further meetings will be held to discuss the rules in still greater detail, and conjoint action will then be taken with the other interests concerned, so that the fullest possible influence may be brought to bear upon the Board of Trade to modify the rules in the particulars finally agreed on.

The Electrical Purification of Sewage.—A few weeks ago we referred to the experiments being made in France with the Hermite system of purifying sewage by means of electrolysed sea-water. This method is being tried at Lorient, and an English commission has recently visited the town to inspect the working operations. A correspondent of the *Standard* was present with M. Hermite and Dr. Mark Armand Ruffer, who had journeyed from London to test the efficacy of the system for the British Institution of Preventive Medicine. The correspondent conducted Dr. Ruffer to the house where the electrolyser has been fixed up. On approaching the shed under which the electrolyser was at work they stepped

over a gutter running with almost completely colourless water. The liquid was entirely odourless, and seemed to have had the effect of cleansing the stone. M. Loire related that the old unused sewer of the former slaughter-house had for years been a fertile sources of epidemic diseases in the town. Very large sums of money had been spent in attempting to purify it, but till now everything had failed. At the very beginning of the experiments with M. Hermite's system he had flushed this sewer with the electrolysed sea-water. Its complete efficacy was, he affirmed, demonstrated by the result. The stench had entirely disappeared, and the masonry now looked as if the sewer had been restored. After leaving the Town Hall, the correspondent accompanied a large party of municipal authorities to the experimental works. Dr. Ruffer considers it his duty to urge a thorough practical trial of the system being made on a large scale in England. The Havre experiments, the correspondent states, have demonstrated that not only can the electrolysed liquid be manufactured in almost indefinitely large quantities, but that at the same time the application of this system, especially in a seaside town, would constitute a very considerable economy instead of adding to the expenditure of the municipality, as it has the advantage of saving all the water usually employed for the flushing of the nightsoil and sink-pipes of houses, as well as the much larger quantity employed in flushing the sewers and washing the gutters. At Havre, for instance, it is calculated that were M. Hermite's system to be adopted throughout the town the saving in water would not be less than 50 per cent. Everyone in the Normandy seaport seems to be in favour of generalising the application of the system. There are various indications that, not only in France, but in other countries the authorities are becoming alive to the importance of M. Hermite's system of electrical sanitation. In France, the municipality of Brest is at the present moment preparing a practical trial of the purifying method, and before the end of December the English colony at Nice will have an opportunity of witnessing practical experiments of the Hermite system, to be made, as at Brest, at the cost of the municipality. The trial at Nice will take place close to the Promenade des Anglais, and on a somewhat larger scale than that made here. At the end of the year, when the experiments at Nice have been organised, M. Hermite is to make a flying visit to Alexandria and Cairo, with the object of arranging for trials of his method in those Egyptian towns. As for Paris, it is becoming every day more probable that the Ile de la Cité will be made the scene of experiments on a large scale. Numerous other municipalities have written to M. Hermite with the object of making experiments with his system.

Physiological Effects of High-Frequency Electric Currents.—Mr. W. S. Hedley, M.D.Edin., in the course of a communication on this subject to the *Lancet* of the 9th inst., states: "Mr. A. C. Swinton's letter in the *Lancet* of October 14 will not only be appreciated by medical men as a valuable contribution to our knowledge of a new and difficult subject, but it will be accepted also as an indication that the electrical expert is willing to aid in the efforts of the profession to decharlatanise medical electricity and to reduce some at least of its problems to a question of sound physics. In referring to an article of mine which appeared in the *Lancet* of August 19, Mr. Swinton correctly states that the view therein adopted that high frequency currents are harmless mainly because of their small current strength is one previously put forward by him in the *Philosophical Magazine* of February last. It might also have been added, and no doubt would have been so had Mr. Swinton been aware of the fact, that before the appearance of the article in the *Philosophical Magazine* I, and before me the *Electrical Review*, had accepted this principle and referred to the 'whittling down' of current strength by the various transformations to which it had been subjected as a probable cause of this and many similar phenomena. This seems to be evidenced by an article on the physiological effects of alternating currents published in the *Lancet* of December 24, 1892, and by the pages of the *Electrical Review*. With the knowledge that exists of the surface transmission of high frequency currents along metallic conductors, Mr. Swinton's explanation of the power of such currents to light incandescent lamps becomes a very probable one; but when the human body becomes the conductor there seems to be no good evidence to show how such currents are transmitted unless (and this the present state of the question seems scarcely to warrant) the physiological effects claimed for them are accepted as a proof that they deeply penetrate the organism. This is a question in biological physics concerning which light and leading are still sought for. Mr. Swinton suggests a general law that, apart from some possible minor influences of frequency and abruptness of alternation, the physiological effects of electric currents are mainly proportional to their electrolytic effects. Other things being equal, this is probably true. But it seems to minimise the importance of other factors, and, taken as a law, to fall far short of the facts. As an instance those most obvious of all electro-physiological phenomena, the neuro-muscular effects that follow electric excitation may be cited. Putting aside for the moment the influence of current density, an old familiar experiment, in which a voltameter, an interrupting wheel, and a frog à la Galvani ('physiological limb') are connected up in a continuous-current circuit, may be considered. With the wheel at rest gas is disengaged and there is no visible muscular contraction. Once the wheel is put into motion evolution of gas nearly ceases, and the muscle is seen to strongly contract. In other words, unless a certain current is made and broken no visible muscular movement occurs. The mere passage of the current, be the electrolytic effect what it may, fails to produce visible contraction. Here motor reaction is proportional to the variation of the potential and to the suddenness with which that variation is made, as well as (no doubt) to the strength of the current used. But the question is not even so simple as this. With the 'interrupted Franklinic' current there is obtained a maximum motor effect with a minimum amount of sensation—viz., violent muscular contraction with practical immunity from pain. How does current strength help here? If smallness of quantity accounts for the absence of sensory effect, it can scarcely be invoked also to account for the marked presence of motor effect. Further, how does such a law cover the phenomena of 'make' and 'break' and the reversal of the formula in the 'reaction of degeneration,' or how does it account for those conditions of altered excitability known as 'anelectrotonic' and 'katelectrotonic'? In these cases there are varying physiological effects with the same current strength. How far the ordinary laws of physics and how far 'vital' endowments of living structure account for such phenomena have yet to be ascertained. It would appear that we must still content ourselves with the statement that the effects of electric currents on the body depend not only upon current strength, but on the mode in which such current strength is presented—*i.e.*, that physiological effects are proportional not only to the quantity of electricity, but also to its modality."

JOHN RENNIE.

Mr. John Rennie, M.I.E.E., was born in Ayr and educated at the Newton-on-Ayr Free Church School. Returning to Glasgow he entered upon business pursuits, taking advantage meanwhile of the excellent evening classes then carried on by the Glasgow Mechanics' Institute. He subsequently spent some years in the shipbuilding yard of Messrs. Barclay, Curle and Co., of Glasgow, where he acquired a practical experience of the various departments of engineering concerned in that industry. In 1876 he entered the University of Glasgow, following the courses in arts (specially physics) and engineering science, holding for three years a Thomson Experimental Scholarship. Towards the end of his term he became secretary and private assistant to Lord Kelvin (then Sir William Thomson), which position he held until 1890, when he received his present appointment, that of electrician to the Board of Trade. In this capacity he is acting as assistant to Major Cardew, electrical adviser to the Board of Trade, especially with reference to the equipment and organisation of the new laboratory recently established by that Department for dealing with electrical standards of measurement.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC.MEM.INST. ELECTRICAL ENGINEERS.

(Continued from page 393.)

ALTERNATE-CURRENT WORKING.

In entering upon this subject the reader must be prepared to tolerate a little elementary mathematics, since the theory of alternating currents cannot be understood without. The whole subject, indeed, is one that calls for a fair mathematical knowledge, and every day the necessity of the study and examination of this branch of electricity becomes more and more compulsory to those who wish to keep pace with the development of electrical science. In direct-current work everything is so simple that those who have only had experience in that branch find themselves quite at sea when called upon to operate alternate-current plant, and this is not to be wondered at. A direct-current engineer has only to multiply his ammeter reading by the voltage of the circuit to obtain the electrical power that is going out; the alternate current engineer cannot do this. If an alternator is working at 2,000 volts pressure, and the current in the primary circuit is 40 amperes, the power given out is not $(2{,}000 \times 40)$ watts. Similarly if the alternating volts be divided by the resistance in ohms of the primary circuit, the quotient will not give the primary current in amperes. It is on this account that it is said that Ohm's law is not true for alternating currents, but it is perfectly true if applied in the right way, and all the other causes and effects are taken into account. There are more E.M.F.'s than one, and there are other obstructions to the current besides the mere metallic resistance of the conductors; they ignore the effects of self-induction and the lagging of the current behind the impressed E.M.F. Only a few of the rudimentary equations can be given here, and those who wish to enter into the subject should consult Dr. Fleming's work, entitled "The Alternate-Current Transformer in Theory and Practice"—the theoretical part is in Vol. I.

The nature of an alternating current has already been explained, and on referring back, Fig. 17 shows the two curves—the E.M.F., and the current that lags behind. It is necessary in dealing with this kind of work to know the value of both the E.M.F. and current at any instant—that is, at any stage of the periodic rise and fall. Suppose we have a coil of wire, as in Fig. 32, capable of rotation, and placed in a magnetic field whose strength is H; let the area of the coil be A, and let it make one complete revolution in the time T, then at any instant t the number of lines of force embraced by the coil are

$$N = H\,A \cos \frac{2\pi t}{T},$$

where the fraction $\frac{t}{T}$ determines the angle in degrees through which the coil has turned.

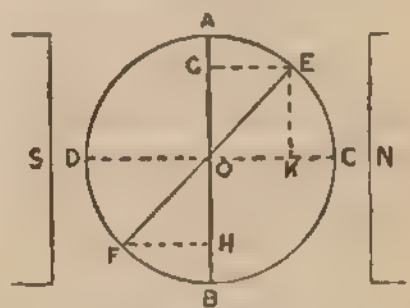


Fig. 32.

The slope of the curve at any point is obtained by finding the tangent of the angle which the curve at that point makes with the horizontal; evidently the angle cannot be greater than 90deg., because then the slope of the curve is at right angles to the horizontal—that is, it occupies a perpendicular position. The maximum value of the tangent is $M\frac{2\pi}{T}$, and when the cosine is diminishing, then the sine curve has a positive value, and *vice versâ*. If we suppose the number of lines embraced to be decreasing, we shall find that the time rate of change, or the E.M.F., E, produced, to be

$$E = \frac{2\pi}{T} A\,H \sin \frac{2\pi t}{T};$$

the expression $\frac{2\pi}{T} A\,H$ is, therefore, the maximum value of the time rate of change of N, and it is also interesting to note that if we have any quantity, N, undergoing variation according to a sine law, then the maximum value of rate of change will be

$$\frac{2\pi}{T} N.$$

The pulsating waves of an alternating current so closely resemble a curve of sines that the non-mathematical reader should establish for himself the following most important facts:

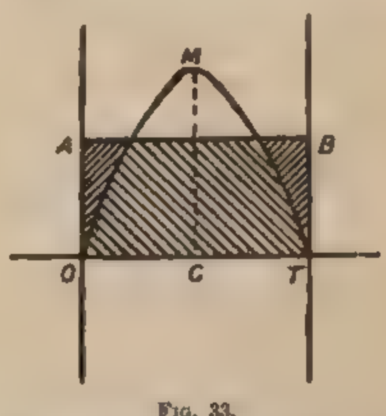


Fig. 33.

(1) The mean ordinate of a sine curve between values 0 and π is $\frac{2}{\pi}$ or $\cdot 637$ M, where M represents the maximum ordinate. In Fig. 33 the area enclosed by the sine curve, O M t, is obtained by multiplying the maximum height, M,

by the base, O t, and then by ·637. The area of the curve between the limits O and t is thus equal to the rectangular area, O A B t, since the ordinate, O A, is ·637 of M. Since the number ·637 is not far from 666, hence we may say that the time average of the fluctuating current is, roughly, about two-thirds of the maximum value of the current.

(2) In measuring an alternating current it is the square of the current that must be considered; hence the average given in (1) is not the true measure of the mean current, but it will be the square root of the mean square, expressed by $\sqrt{\frac{M^2}{2}}$ or $\frac{M}{\sqrt{2}}$, because the square of the maximum value is M^2, and the mean square is $\frac{M^2}{2}$; so that we have two mean values, the first being ·637 of the maximum, or the simple arithmetical mean, and the second being $\frac{1}{\sqrt{2}}$, or ·707 of the maximum, or the square root of the mean square. This last expression is now written thus, $\sqrt{\text{mean sq.}}$ for terseness. The difference between ·637 and ·707 is ·07, which thus shows that the simple mean is 10 per cent. below $\sqrt{\text{mean sq.}}$ Draw two sine curves, one of which is retarded by a small angle, ϕ, behind the other; multiply their ordinates together at every point, and take the mean value; increase the retardation, ϕ, and repeat the operation, and we shall find that we get a smaller result. Make ϕ = 90deg., so that the second curve commences at a quarter of a period behind the first curve, and we shall find that our result is now zero, and no work is done

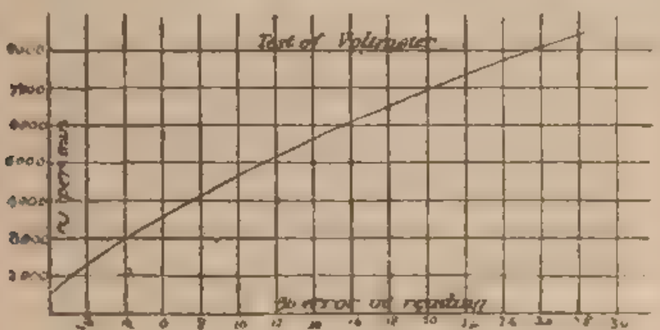


Fig. 34.

because the positive products exactly equal the negative products. If this operation be repeated for several values of ϕ, we shall find that the average value for a given value of ϕ is A B cos ϕ, where A and B are respectively the maximum ordinates of the two sine curves under examination. In an alternate-current circuit the current would be equally in phase with the impressed E.M.F., if it were not for the disturbing effect of self induction, which causes the current to be retarded, or to lag behind the impressed E.M.F. The following experiment illustrates how self-induction produces erroneous readings when ordinary measuring instruments which are made for direct-current work are used for alternate current work.

A horizontal coil, having a resistance of 1,158 ohms and consisting of 1,150 convolutions, has suspended at its centre a smaller coil, having a resistance of 65 ohms and 2,150 convolutions, the axis of the smaller coil being at right angles to that of the larger. The ends of the two coils are connected in series, and are then first joined up to a source of steady E.M.F. and the deflection of the small coil noted; the circuit is then broken, and the ends of the coils are joined up to a source of alternating E.M.F. of equal amount, when it is found that the deflection is much less; in fact, in one case, when the "frequency," or "periodicity," of the current was 260 per second, the deflection was 15 per cent. lower than the deflection obtained from a direct E.M.F. of equal amount. The accompanying curve shown in Fig. 34 shows the percentage of error observed when a voltmeter containing iron, and constructed for direct currents and steady E.M.F.'s, was used with alternating E.M.F.'s of various periodicity. With a periodicity of 133 per second, the reading on the voltmeter was no less than 26 per cent. lower than what it would be if the E.M.F. were steady, instead of being of an alternating character. The above experimental fact teaches us one very important lesson, and this is: that wherever there is any iron present in an alternating-current circuit, it will create self inductive disturbances. Therefore all instruments for measuring alternating currents, whether ammeters, voltmeters, or wattmeters, must be constructed free from iron.

An alternating current circuit may be one of two kinds—inductive or non-inductive. We will consider the latter kind first, as it is the simpler: a non-inductive circuit signifies one that has no self-induction, consequently the only obstruction to the current is the actual ohmic resistance of the conductors.

To measure the alternating current, we should take an electro-dynamometer, which will measure the $\sqrt{\text{mean square}}$ or $\frac{I}{\sqrt{2}}$, where I signifies the maximum value of the current; similarly, to measure the alternating volts, we should use a Cardew voltmeter, which will measure $\sqrt{\text{mean square}}$ of the impressed E.M.F., or $\frac{E}{\sqrt{2}}$, where E signifies the maximum value of the impressed E.M.F. Having now obtained both the current and the volts, the product of the two readings will give us $\frac{E\,I}{\sqrt{2}\,\sqrt{2}} = \frac{E\,I}{2}$, and this represents the mean power consumed.

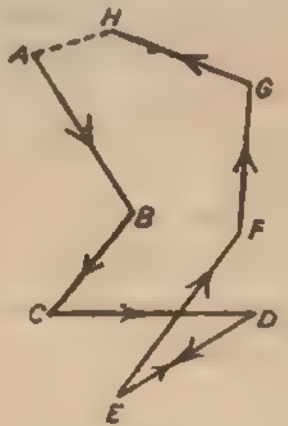


Fig. 35.

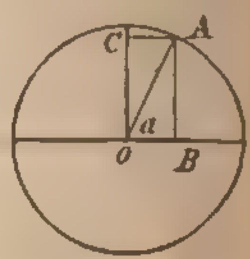


Fig. 36.

The above is true when both the E.M.F. and current are in step or in phase, but suppose that the current curve is retarded, and lags 60deg. behind the E.M.F. curve, then we shall have

$$\text{mean power} = \frac{E\,I}{2} \times \cos 60\text{deg.} = \frac{E\,I}{4}.$$

A graphical view of this is given in Fig. 35.

Suppose we have a number of forces acting on a point, it can easily be shown that if lines are drawn parallel to these forces, and proportional in length to the forces represented, and to some fixed scale, so that in direction and magnitude they may symbolise the several forces, then if all the forces are in equilibrium, the figure obtained will be a closed polygon, and if they are not in equilibrium, the figure will be open. For example, suppose A, B, C, D, E, F, G, H represent such a polygon, obtained from a number of forces, and open at A H, then the dotted line A H represents the resultant of all these forces. We shall now show that we can equally as well apply this to E.M.F.'s acting in a circuit. In an alternating current circuit we have usually three E.M.F.'s acting:

(1) The effective E.M.F., or the product C R.

(2) The E.M.F. due to self induction or inductance.

(3) The impressed E.M.F., which at any instant balances the other two.

Suppose we have a line, O A (in Fig. 36), revolving about a point, O; if O A represents to some scale the maximum value of an E.M.F. undergoing a sine variation, it will be

seen that we may represent the values at any instant by the projection of the line O A upon a fixed line, such as O C, which it will be seen is proportional to sin a. Now O A may represent the resultant of any number of E.M.F's. We may extend this, as in the case of the force polygon, and state that the projection of the resultant of any number of E.M.F.'s is the sum of the projections of its constituents.

An inductive alternating-current circuit is a much more complicated matter to deal with than the other, since we have to consider the disturbing effects of self-induction to obtain the power consumed in an inductive circuit. We must not multiply the $\sqrt{\text{mean square}}$ of the alternating current by the $\sqrt{\text{mean square}}$ of the alternating E.M.F., because the product would not measure the true mean power. The mean power at any instant of time, is obtained by multiplying the current at that instant by the E.M.F. at that instant; the same must be done for any and every other instant. We thus have a series of simultaneous results, and the mean value of this series will give the true mean power consumed. The product of $\sqrt{\text{mean square}}$ current and $\sqrt{\text{mean square}}$ E.M.F. is called the *apparent* mean power consumed in an inductive circuit; whilst the mean of the products of current and E.M.F. is called the *true* mean power consumed in an inductive circuit.

For a non-inductive circuit, or when the current curve is in step with the E.M.F. curve, the $\sqrt{\text{mean square}}$ current $\times$ $\sqrt{\text{mean square}}$ E.M.F. = mean product of current and E.M.F.; but, as explained above, this is not so with an inductive circuit, or when the current curve lags behind the impressed E.M.F. curve. In some cases the true watts may be only one-half what the apparent watts are.

In an inductive circuit we have to deal with self-induction, which may be defined as the E.M.F. that is produced by the varying current acting inductively on its own circuit. Where the current is a steady one—that is, of constant value—there is no effect apparent of self induction, because the magnetic field enclosing the current is invariable in strength; but immediately the current begins to

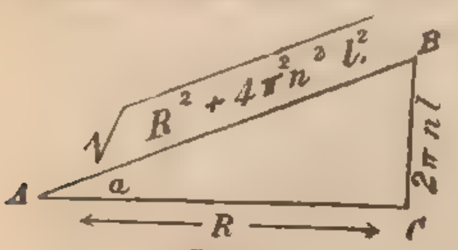


FIG. 37.

change and vary in value, like an alternating current, its magnetic field also begins to change in value, and when a conductor is surrounded by a magnetic field which is constantly varying in strength, an E.M.F. is set up which is opposite in force to the impressed E.M.F. of the circuit; thus in addition to the mere resistance in ohms of the conductor, there is a second obstruction to be dealt with. The obstructive effect which this counter E.M.F. has upon the current of the circuit is named the "inductance" of the circuit. Hence, we may say that a circuit has unit inductance when a current varying at the rate of one ampere per second will produce in it an E.M.F. of one volt, and this unit is named a "henry," or a "secohm," and is generally denoted by the letter L.

When the periodicity of the current is n ∿ per second, then the inductance is measured by $2\,\pi\,n$ L; where L is the said coefficient of self-induction, let the resistance of the conductors be R ohms, then the total obstruction to the current is $\sqrt{R^2 + (2\,\pi\,n\,L)^2}$, and this is named the impedance of the circuit, since it represents the whole resistance which the current has to contend against. Fig. 37 shows the relation between inductance and resistance, where resistance and inductance occupy two sides of a triangle, A C = R and B C = $2\,\pi\,n$ L, then the hypothenuse, or third side, A C, must equal the $\sqrt{\text{sum of the squares}}$ = $\sqrt{R^2 + 4\,\pi^2\,n^2\,L^2}$; hence the side A B = the impedance of the circuit. Suppose in a circuit having inductance whose coefficient is L, resistance = R, and impressed E.M.F. = E, that the maximum value of the current be I, then the product R I represents the volts absorbed by the metal resistance of the circuit, and these volts are named the effective E.M.F. The product ($2\,\pi\,n$ L) I will represent the E.M.F. due to the inductance of the circuit, whilst the product $\sqrt{(R^2 + 4\,\pi^2\,n^2\,L^2)}$ I will represent the impressed E.M.F. of the circuit. The angle B A C in Fig. 37 always defines the lag of the current I behind the impressed E.M.F.—that is, it measures the angle of retardation in phase—while its tangent represents the ratio existing between the inductance and resistance of the circuit. We can now give a rough formula for the adaptation of Ohm's law for alternating currents, which is—

$$\text{Current} = \frac{\text{impressed E.M.F.}}{\text{impedance}}.$$

Mathematically this may be expressed—

$$C = \frac{E \sin \theta}{\sqrt{R^2 + 4\,\pi^2\,n^2\,L^2}}.$$

The following experiments have been made by Mr. W. Brew, of the British Museum, and have been kindly supplied to the writer as illustrating some interesting results on the skin effect of alternating currents in conductors.

Skin Effect.—The method of experiment consisted in observing the increase in the force exerted upon a magnet pole reversing in synchronism with the alternate current, and placed just exterior to the conductor in which it was flowing. As the rate of alternation of the current was increased from zero upwards the current was forced outwards to the external layers of the conductor, and the force exerted upon the magnet pole was correspondingly increased.

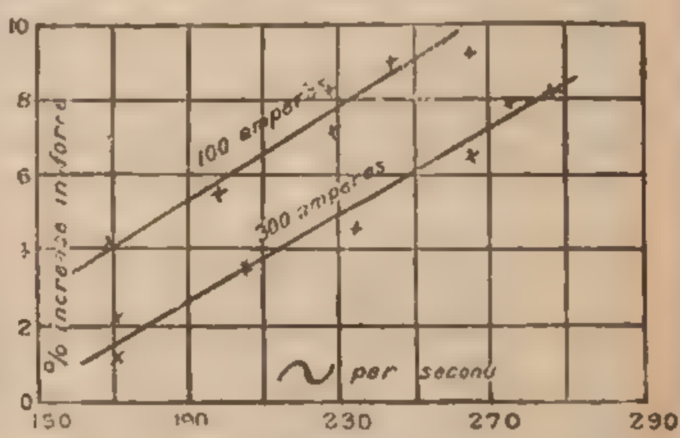


FIG. 38.

In one experiment, using a solid brass conductor 1in. in diameter, and passing various currents of a frequency of 200 through it, it was found that the force on the magnet pole had increased by about 20 per cent. of its original amount with continuous currents of equal value flowing in the conductor.

In another experiment a brass tube of the same external diameter, but ⅞in. internal diameter, was employed, and some of the results obtained are plotted in the accompanying curves, having for abscissæ the frequency of the alternating current and as ordinates the percentage increase in the force exerted upon the magnet pole over that due to a continuous current of the same numerical value. The upper curve was obtained with a current of 100 amperes at various frequencies, and the lower curve refers to a current of 300 amperes passing through the conductor under similar conditions.

The curves show us, amongst other things, that with a low current density the skin effect becomes more apparent than with a high one; also that after about 16,000 alternations per minute, or a frequency of 266 has been reached, the current rapidly becomes forced to the external layers of the conductor.

(*To be continued.*)

POLYPHASE ALTERNATE CURRENTS.

(Continued from page 543.)

It has been shown that, speaking theoretically, the field produced by two or three currents is constant, but we find as a matter of practice that it is not so. The presence of iron in the inductive system gives rise to hysteresis; and, conversely, the armature also reacts upon the field; alternating currents therefore can only be called more or less sinusoidal.

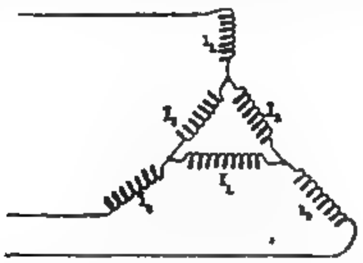


FIG. 15.

As a consequence the field varies from time to time above and below its theoretical value, and these variations are inversely as the number of coils in the field system. According to Messrs. Siemens and Halske's experiments, the variations were as much as 13 per cent. with only four coils, although they practically ceased when six coils were used with six currents displaced one-sixth period. In order to obtain a rotating field of constant strength, we might use a considerable number of alternating currents of different phases, but this would of course introduce many complications in producing and transmitting the currents. A simpler way is to vary the windings so as to increase the number of component fields, but not of the different-phased currents. To effect this we may employ any one of three methods:

1. A combination, see Fig. 15, of the two arrangements already mentioned—star-shaped and triangular. It is obvious that the currents circulating through the centre coils are displaced one-sixth of a period with respect to those in the outer coils. In a mixed winding of this kind

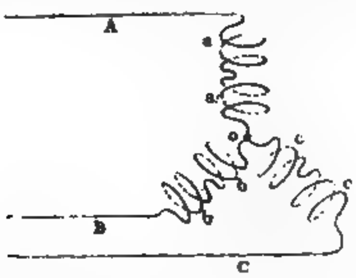


FIG. 16.

we have therefore six currents, each differing in phase by one-sixth of a period. By suitably arranging the resistances of the different coils we may obtain currents of the same strength.

2. Three alternating currents, A, B, C, of the same period and amplitude, but differing in phase by one-third of a period. According to this method (see Fig. 16), the coils *a a'* are wound in opposite directions, similarly with *b b'* and *c c'*. The result is the same as if the second coil in each case

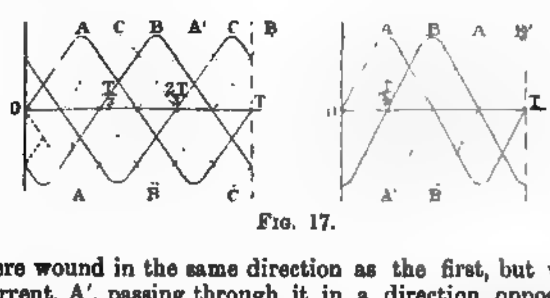


FIG. 17.

were wound in the same direction as the first, but with a current, A', passing through it in a direction opposite to that of A; and we have six currents differing in phase by one-sixth of a period, and succeeding one another in the *order* A C', B A', C B' (see Fig. 17). Similarly, we can get four currents displaced one-fourth period by the use of two currents displaced to the same extent.

In the case of a field produced by six currents, if H = the field strength produced by a current, A, passing through one of the six windings, it is obvious that the strength of the rotating field at each instant is 3 H, and that it makes one revolution per period of the alternating currents. The algebraic sum of these current strengths has a zero value throughout.

3. A still further step in this direction has been taken by Dobrowolski, who shows that when we superpose two currents of the same period, T, and strength, *c*, but

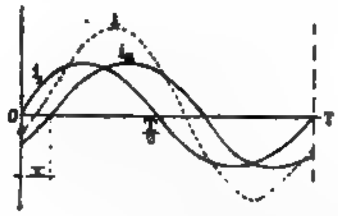
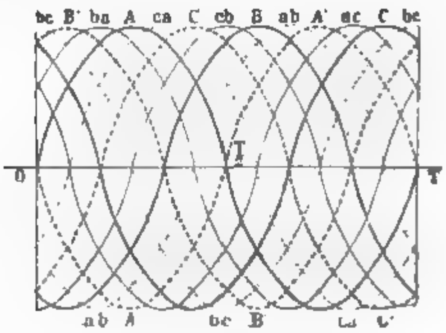


FIG. 18.

differing in phase by an interval, x (see Fig. 18), the current strength $C = 2c \cos \frac{x}{2}$. The first method above mentioned is in reality based upon the principle underlying this formula.



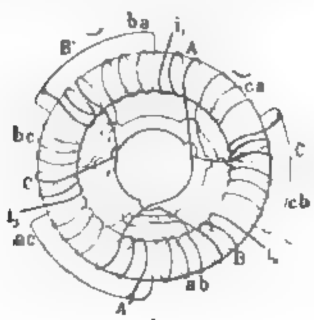


FIG. 19.

We can adopt as a combination of the two preceding methods the system shown in Fig. 19, where the windings are in opposite directions upon the coils—thus:

A and A'	B and B'	C and C'
a b and *b a*	*a c* and *c a*	*b c* and *c b*.

Their resistances are so arranged that the ampere-turns on each are identical. With only three currents displaced by a period of $\frac{T}{3}$ we therefore obtain the same effect as with 12 currents differing in phase by $\frac{T}{12}$. The resulting curves are shown in Fig. 19.

MULTIPOLAR FIELDS.

All the fields that we have so far examined (di-, tri-, and multiphase) have been bipolar. The alternating currents—whatever their number—produce a field of two poles, making one revolution per period of the currents. Under certain conditions, however, it is advisable to run more slowly—that is, we may aim at obtaining a field of m poles rotating with a speed $\frac{1}{m}$ of the current frequency. Of course, this result may be achieved by using two, three, or

more currents. In Fig. 20 are shown two examples of such arrangements, and they are sufficiently clear to need no detailed description beyond pointing out that one represents a diphase four-pole rotating field, and the other a similar field, but for triphase currents.

Instead of the windings shown—which are the simplest—we may have on each one of n sections a winding of the type already mentioned, and which will give with two or three currents the same effect (as regards a constant field) as might be obtained from four, six, or twelve currents.

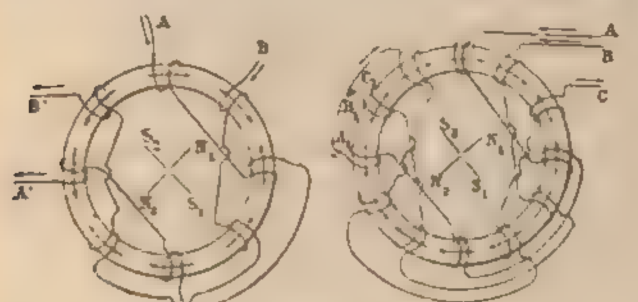


Fig. 20.

With reference to the strength of a multipolar field produced under these conditions, it is not easy to state in general terms its value at any particular instant. In drawing a curve to represent current strengths, it is evident that we have a multipolar field making $\frac{n}{m}$ turns per second (n being the frequency of the currents), but its strength is far from being constant.

The Armature.

Whichever method be employed to produce the rotating field, we use with it an armature whose windings are closed upon themselves. The rotating field develops in the armature currents which create a rotating magnetic field in the latter: this second field follows the motion of the first, and so makes the armature rotate, but at a speed considerably less than that of the first field. If the speed of the armature were equal to that of the first field, the flow of energy through its coils would be constant, and there would be no E.M.F. induced therein.

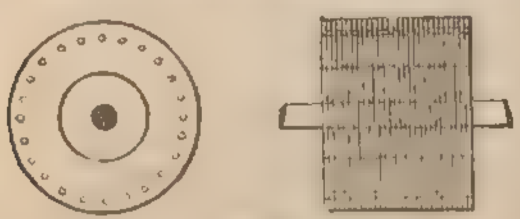


Fig. 21.

A winding is therefore chosen of such form as shall offer the least possible resistance to the currents due to the E.M.F. induced in the coils. The strength of the field produced by the coils is not increased by multiplying the number of turns (for an equal weight of copper), for the resistance being proportionally greater, the magnetomotive force, which varies with the ampere-turns, would remain the same. The only result would be to complicate the machine.

On the other hand, to employ a continuous winding of copper would prove disadvantageous by reason of the magnetic resistance, and in such a winding—as in a heavy iron armature—the currents would not necessarily take the course best adapted to generating a field. It is true that massive iron armatures have been used for small motors, but their consequent simplicity of design is hardly made up by the low efficiency.

In practice the construction shown in Fig. 21 is employed. The armature core, whether of drum or ring type, is built up of thin plates of sheet iron, well insulated in order to avoid Foucault currents. These discs are pierced with holes parallel to the axle, and drilled on a circular line near the outer circumference of the core. The armature conductor wires are passed through these holes, and thus constitute a winding which has the advantage of allowing a very small air-gap, and hence a reduced magnetic resistance.

In a bipolar rotating field, the conductors diametrically opposite are joined so as to form a complete closed loop; but there is another way of connecting them so as to save copper and give a more easy construction, both methods having the same result so far as the induced currents are concerned. In the second system of connection, the conductors are all joined together by two annuli or discs of copper, as shown in Fig. 22.

We may also wind the armature according to any of the methods already dealt with in discussing the field system.

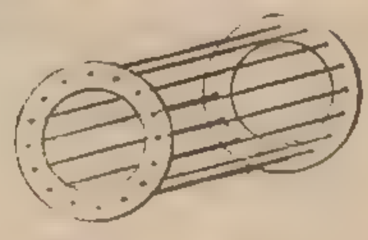


Fig. 22.

In such a case (using, for instance, triphase currents) the three free ends of the armature windings are led to three rings on the axle; and variable resistances may be introduced to prevent the current from reaching a strength too high for the conductors employed.

The Power Developed in a Motor.

If ω_1 represents the angular velocity of the rotating field, and ω_2 that of the armature, it may be shown that the total couple exerted is given by the equation

$$C = \frac{p\,\omega^2 N^2 l}{2\,r^2 + \omega^2 l^2},$$

where p = number of coils; r = the resistance of one coil, closed on itself; N = the lines of force due to the inductive field influencing the armature; $\omega = \omega_1 - \omega_2$, or the absolute value of the armature speed compared with that of the field; l is obtained from $\tan \phi = \frac{\omega\, l}{r}$. For the given machine, and for a fixed value of ω, it is evident that C is constant.

When ω tends towards zero—that is, when the armature rotates at a speed almost the same as that of the field—C also diminishes; on the other hand, C increases with ω. The maximum value of ω is given when $\omega_2 = 0$—that is, when the armature is at rest. The power developed is—

$$P = \omega_2\, C.$$

The calculation of a maximum value for P is rather long and complicated: the result is dependent upon the maximum value of ω, which again depends upon r, l, and ω_1—that is, upon the constructive details of the motor, and upon the frequency of the currents which pass into it.

Efficiency.

Losses Due to Resistance of Field System.—These depend upon the size adopted for the windings, and practically a calculation, similar to those carried out with other electrical machines, must be made. Questions of heat waste, conducting surfaces, etc., must all be considered; but all told, the losses in this direction for a well-designed machine will be quite insignificant, and should not in any case exceed, say, 3 or 4 per cent.

Losses due to Hysteresis and Foucault Currents.—These are proportional to the mass of iron employed, the magnetic induction passing through it, and the frequency of the alternating currents which form the supply. They may all be ascertained in a machine of given dimensions, etc., taking as a base for calculations the specific loss known to be incurred by transformers working under the same conditions as to frequency and strength of magnetisation; but it is not possible to arrive at their value in any general fashion.

It may, however, be noted that these losses will be the greater in proportion as the magnetic induction rises and the period of alternation diminishes. With regard to the

latter, we must distinguish between the field and armature. The period T_1 of the field is given by the equation :

$$\omega_1 = \frac{2\pi}{T_1};$$

that is, in the case of a bipolar-field system, in which the rotating field makes one turn per period. This period depends solely upon the currents entering the motor.

In the armature, *per contra*, the period of the currents is given by the equation :

$$T = \frac{2\pi}{\omega}.$$

Bearing in mind that $\omega = \omega_1 - \omega_2$, it is evident that T will always be much greater than T_1. To diminish the losses due to hysteresis and Foucault currents, it is advisable to reduce the iron in the field system to a minimum. This leads to the use of fields placed inside the armature, and of currents with long periods of alternation.

Loss Due to Armature Resistance.—The value of this loss is given by the equation :

$$\Sigma r c^2 = \frac{p}{2} \frac{\omega^2 N^2}{r} \cos^2 \phi.$$

The electrical efficiency in the armature is obtained from the following expression :

$$E = \frac{\omega_2}{\omega_2 + \frac{r}{l}};$$

but as we have already seen, $\tan \phi = \frac{\omega l}{r}$,

whence $$\cos^2 \phi = \frac{r^2}{r^2 + \omega^2 l^2};$$

so that whatever the speed, ω_2, of the armature may be, E will increase inversely as r and directly as l.

On the other hand, the greater ω_2 becomes, the more E tends towards unity ; but it must be noted that the power developed is a maximum when $\omega_2 = \omega_1 - \omega$, and that above such a value of ω_2 the power developed is reduced to zero when $\omega_2 = \omega_1$—that is, when the motor is running unloaded.

The Coefficient of Self Induction in the Armature Coils.

The magnetic flow produced by the currents induced in the coils is always normal to a plane making a given angle, ϕ, with the direction of the rotating field at the same instant. Resolving the flow due to each coil, in two directions, and summing the components, it is easy to show that the flow through any coil is given by the expression :

$$\frac{1}{R} 2\pi p \frac{\omega N}{r} \cos \phi \cos(\alpha - \phi) = l c,$$

where R = the magnetic resistance of the entire magnetic circuit.

Hence $$l = \frac{2\pi p}{R}.$$

(To be continued.)

ON THE ORIGIN OF THE FACTOR 4π IN THE EXPRESSION FOR THE MAGNETOMOTIVE FORCE OF A COIL.

BY A. E. KENNELLY.

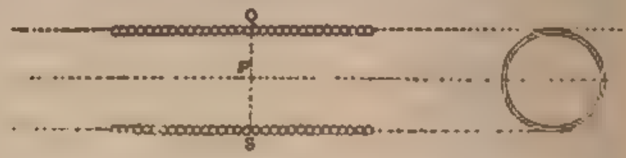
The magnetomotive force of a coil or solenoid is known to be $\mathcal{F} = 4\pi N C$ C.G.S. units, where N is the number of convolutions in the coil, and C is the current strength in C.G.S. units (of 10 amperes), so that, expressing the current strength in amperes by c, the formula becomes

$$\mathcal{F} = \frac{4\pi}{10} N c \text{ units.}$$

Since enquiries are frequently made concerning the origin and object of the coefficient 4π, we may here examine its *raison d'être.*

It may first be seen by two different methods of procedure that the intensity of magnetic flux within an indefinitely long, straight, hollow solenoid is $4\pi n C$ units where n is the number of turns in the solenoid per centimetre of its length, and then the main proposition will be immediately deducible.

Let r (centimetres) be the radius of the solenoid extending to infinity in both directions and partly represented in longitudinal and cross sections in the figure. The current, C may be supposed to be constantly circulating in every turn.



At any point, P, on the axis of the coil the intensity is due in some degree to each of all these turns. The greatest share is provided by the nearest turn, P Q S, immediately surrounding P. The intensity at P, due to this turn alone, is $\frac{2\pi C}{r}$. The share of intensity supplied by succeeding turns on each side diminishes steadily, and turns indefinitely remote obviously contribute an indefinitely small portion. The share contributed by any one turn situated at a distance, x, from P, measured along the axis, is $2\pi C \cdot r^2/(x^2+r^2)^{\frac{3}{2}}$.

The total intensity at P is the sum of all the terms of this type supplied by all the turns, or in mathematical language is the integral of the expression $\{2\pi C r^2 / (x^2+r^2)^{\frac{3}{2}}\} dx$ between the limits of positive and negative infinity in the variable, x. This integral is $4\pi n C = \frac{4\pi}{10} n c$, which represents the intensity at P in C.G.S. units, n being the number of turns per linear centimetre. This result is independent of the radius of the coil, and it can also be shown that the above intensity is not restricted to the axis, but has a constant value over the cross-section. In other words, the intensity is uniform within the solenoid, and equal to $\frac{4\pi}{10} n c$ units.

It is also evident that the flux density must be uniform over the cross-section of the long straight solenoid, from the fundamental principle that uniform flux density accompanies uniform flux curvature. The flux through the solenoid must follow straight lines parallel to the axis, except near the ends of the solenoid, and has therefore no curvature at any point of the cross-section. Its curvature being everywhere zero, its density is everywhere equal. On the other hand, the flux through a single turn of active conductor, or a very short solenoid, is nowhere parallel or uniformly curved, and the density nowhere uniform.

The same result can also be reached independently, as follows: The fundamental law of an indefinitely long solenoid, having unit cross-sectional area and n C current-turns per centimetre, is that it conveys a magnetic flux capable of producing at its ultimate extremities magnetic poles of strength n C. A unit magnetic pole is an ideal magnetic point source establishing unit intensity at a radial distance of 1cm. in every direction, and consequently all over a spherical surface of 1cm. radius, or 4π square centimetres in area. The unit pole therefore disperses 4π C.G.S. unit lines, so that the solenoidal pole of strength n C disperses $4\pi n C$ units, which flux must traverse the whole length of solenoid. But the interior cross-section being taken as one square centimetre, the density of this flux must be $4\pi n C$ units per square centimetre, or $4\pi n C = \frac{4\pi}{10} n c$ units.

Returning now to the consideration of magnetomotive force, we have the fundamental relation $\frac{\mathcal{F}}{\mathcal{R}} = \Phi$, where $\mathcal{R}$ is the total reluctance of the circuit in C.G.S. units, and Φ is the total flux, consequently $\mathcal{F} = \mathcal{R}\Phi$.

The reluctance of an infinitely long straight solenoid is all within it ; for although the exterior curved paths of returning flux must be longer than the interior straight path from pole to pole, yet the exterior path is infinitely wide, so that the reluctance of the external portion of the

magnetic circuit or air-gap between the poles is insignificantly small by comparison. In the case, then, of the magnetic circuit comprised by a long solenoid whose cross sectional area is unity, the reluctance would be one unit per linear centimetre, and if the very great length of the solenoid were denoted by X (centimetres) the total reluctance of the circuit would be X units to a high degree of approximation, and which would be exact for an infinitely long solenoid. We have also seen that the total flux would be $\Phi = 4 \pi n C$ units, and consequently

$$\mathcal{F} = X . 4 \pi n C \text{ units},$$

but $n X = N$ is the total number of turns in the solenoid, so that $\mathcal{F} = 4 \pi N C$, and the magnetomotive force is 4π multiplied by the current-turns, or $\frac{4 \pi}{10}$ multiplied by the ampere-turns on the circuit.

This rule for arriving at the magnetomotive force of an indefinitely long straight solenoid in which the air-gap reluctance is indefinitely small, applies immediately to a closed or endless solenoid—of the ring type—in which no air-gap exists. It also extends generally to any form of magnetic circuit, including or excluding iron. In general, however, the reluctance of such circuits and the intensity within them will be very complex, but any loop of conductor carrying a current of c amperes may be regarded as developing a separate magnetomotive force of $\frac{4 \pi}{10} c$ units.

INSTITUTION OF ELECTRICAL ENGINEERS.—Dec. 14

The annual general meeting was held at the Institution of Civil Engineers last night, when, in the first place, the usual formal business of reading and confirming the minutes of the last meeting was carried out.

The following gentlemen were balloted for:

Associate.—David Lowdon, Barry Graving Dock, Barry Dock, Glamorgan.

Student.—Henry Edward M. Kensit, care of Dr. Parker, Colne Valley, Rickmansworth, Herts.

After this formal business, the **President** referred in touching terms to the loss sustained by science in the death of Prof. John Tyndall. He mentioned that although the late professor was seldom seen at their meetings hardly one among them but was largely indebted to his writings for a knowledge of science, and none of the frequenters of the Royal Institution could ever forget the unrivalled powers of the late professor in presenting a scientific subject to his hearers so that the meanest intellect in the audience could understand. He concluded by proposing that the secretary send to Mrs. Tyndall a vote of condolence, expressing the sympathy of the society in her bereavement. This was seconded by **Prof. Hughes**, and carried unanimously.

The **Secretary** read the annual report, which stated that the number of members elected during the year had been greater than last year, the numbers being: Foreign members, 6; members, 18; associates, 101; students, 98; total 223. There have been 16 names transferred from the associates to members, and 58 from the students to associates. The Council had to regret that the losses during the year were heavy—namely, three foreign members, 12 members, 11 associates, and one student. The resignations, too, were numerous, consisting of five foreign members, eight members, 12 associates, and 11 students. The list of the Institution has increased by some 160 names, and about 40 candidates have been approved for the ballot at the first meeting next month. The Institution premium of £10 had been awarded to Mr. Sayers for his paper, but this year no other premium had been awarded. It was known to the members that Sir D. Salomons had generously increased his scholarship fund, hence the Council had been able this year to award two scholarships—to Mr. Riddle, of King's College, and Mr. Morris, of University College. Also a premium of £3. 3s. for the best student's paper had been awarded to Mr. Cooper.

Reference was made to the good attendance at the President's conversazione and at the annual dinner.

It was pointed out that through the generous hospitality, the members could meet in the rooms of the Institution of Civil Engineers, yet the time might come when it would be necessary to have a habitation of their own, therefore the Council contemplated setting aside an annual sum for a building fund, and had the matter still under consideration.

When the finances of the year came to be made up, it would be found that they were satisfactory, and a good surplus had accrued.

The **President** moved the adoption of the report, and called, evidently by pre-arrangement, on Mr. Ansell to make some remarks upon it.

Mr. Ansell ventured to ventilate a burning question, and one upon which a large body of members felt deeply. They had prepared a draft memorial, which was being signed for presentation to the Council. This memorial called attention to the desire of the members that all classes of members should be duly represented on the Council. In 1889, owing to an agitation, the Council was made representative, but as the members retired, representative members of a particular section were not re-elected. It pointed out that the telephonic interest, the private telegraphs, and the railway telegraphs were now not at all or insufficiently represented; and suggested that the twelve ordinary members of the Council should be constituted as follows: three to represent pure science, two the electric lighting industry, two public telegraphs, one railway telegraphs, one private telegraphs, one telephony, and two the manufacturing section; and that when any representative of any section retired, another representative of that section should be elected. It was suggested that 12 members of any section could propose a representative, and send in the name for the consideration of the Council by November 1 in each year. He went on to warn the Council that unless these interests were duly represented there would be a large secession of members. He pointed out that the magnificent institution that greeted them to-day was founded upon the action of the old-time telegraphist, and although the telegraphist had long since been passed in scientific knowledge, and perhaps in influence, to them a debt was owing, and they claimed representation. In referring to his own personal position, Mr. Ansell pointed out that since 1845 he had been actively engaged in telegraphic work, and was the sole remaining old-timer on the active list. Five men were still living, but not actively engaged, out of 84 who were in the thick of the fight in 1846. One friend had come to honour their meeting of that evening in the person of Mr. Wilkins, who had built the first telegraph from Thorpe to Norwich, using the old five-needle instrument.

The **President** interrupted the speaker, and said that possibly a majority of the members and of the Council agreed with Mr. Ansell, and suggested a committee of the memorialists to confer with the new Council on the subject.

Mr. Ansell agreed, and the report was adopted.

The next business was in giving various votes of thanks, which, although partaking of a formal character, are nevertheless fully recognised as expressing the full opinion of the members.

Prof. Fleming proposed the vote of thanks to the Institution of Civil Engineers for the continued use of their rooms, which was duly seconded and carried.

Mr. A. Siemens proposed the vote of thanks to the foreign secretaries, one of the best known of whom—Mr. Aylmer—was present. This was seconded by **Mr. Evered** and carried.

Sir D. Salomons proposed the vote of thanks to the hon. auditors, Mr. Danvers and Mr. Streb, which was seconded by **Prof. Hughes** and carried unanimously, as was that proposed by **Mr. Mordey**, and seconded by **Mr. Wright**, to give a vote of thanks to the hon. solicitors.

The **President** stated that the scrutineers had reported the house list of President, Vice-President, and Officers, as given in our last issue, duly elected.

The discussion on Prof. Forbes's paper was then resumed.

Mr. Ferranti referred to the submission to the Cataract Construction Company of designs, which, although they were not found satisfactory in the carrying out of the whole of the details, yet they formed a very good basis upon which to design a dynamo. He referred to the records of the Patent Office, where he had provisionally protected a method of oil insulation of the armature for conveying away the heat in the machine, but found that the method was wrong, and he did not endeavour to secure complete protection. He recognised in the design of the dynamo a feature of the C. E. L. Brown machine, perhaps the man who had had the most experience in that class of work for long distance transmission. He noticed the winding was of strip, and insulated with mica, that was the design sent in by Mr. Brown. He thought it was a very general practice among English engineers to circulate water continually in the jacket around the bearings. It would be effectual in this particular case if the water was continually on. He regarded the method of exciting in series anything but the best. Concerning the dynamo being built by the Westinghouse Company, he was surprised to see, after the failures and successes of high-tension work, that they had not gone in for more than 2,000 volts. There was a great difference between designing dynamos and building them, and also in getting together a collection of information in the world, and then without any previous knowledge of dynamo design, building and running, to fulfil great expectations. This was a point of the greatest difficulty in the Construction Company's scheme. He then dealt with the pressure of 20,000 volts, and compared it with the 10,000 volt current used at Deptford. The subway with high E.M.F. would, he believed, be a very hot place: 10,000 volts was bad enough, but 20,000 volts might be worse, and an accident might lead to a complete breakdown of the system. The subway might, perhaps, be the most unsatisfactory part of dealing with the question. He could not agree with the periodicity of 16·2 per second, even with 25 periods a considerable amount of lighting would be done, and the most practicable was by direct transformation from the high-pressure mains. The periodicity adopted by Messrs. Ganz—viz., about 40, was more satisfactory. It certainly rendered both arc and incandescent lighting possible, and was somewhere about the happy medium. He made some very stringent remarks on the manner in which the company had obtained designs from experts in different countries. This side of the question was most important. It was upon the work of the world that the undertaking would be carried out, but he did not attach any blame to Prof. Forbes in the matter.

(*To be continued.*)

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TRACTION.

The unknown is gradually being obliterated from the question of the cost of electric traction. In the early days of any industry, business must be transacted more or less from the basis of estimated cost. Then, after a practical attempt at work has been carried out, time is necessary to show the exact cost, and to take the matter from the region of fancy into that of fact. Electric traction is being developed in two ways—one as the motive power on what are practically railways, and the other to replace horse traction on tramways. There is a vast distinction between the two cases, and we are not sure but most people will agree that the railroad problem is the simpler of the two. Dr. Edward Hopkinson, in his lecture at Owens College, has given the cost of electric traction on the City and South London line at a fraction under 6½d. per train mile. The estimate of the contractors before the work was commenced led them to guarantee that the cost should not exceed 8½d. per train mile. We have to point out that the City and South London line was originally intended to be worked by cable, and probably its design would have been considerably altered had electric traction been determined from the first. Then, again, this was actually the first line of its kind, and however experienced constructors of dynamos and motors and the other paraphernalia of electric traction may be, it is absolutely certain that a second venture of a similar fashion would in some measure be better than the first. Experience must be a guide, and perfection is not obtained at the first trial. Hence, with a line designed from the first for electric traction, and with the improvements that experience will suggest, we should expect another line to be worked at even a less cost than 6½d. per train mile. It is estimated that with a quicker train service the existing line could be worked for about 4d. per train mile. Now, with the exception of this last estimate, which we should say is amply warranted by facts, the other expenses are facts, and cannot be gainsaid. They prove our contention that even now in many instances electricity is a better and a cheaper power than steam. It is not, however, so much on railways that our hopes for immediate development are directed as on tramways; though Liverpool has followed South London, and is amassing further facts to prove these views. But in England, at any rate, the tramway authorities are hard to move. There are good reasons in many cases for this, but we hope better reasons will prevail and bring about a great change. It is rumoured that Newport, Mon., which has lately decided upon adopting the electric light, the work for which is being carried out, will not be averse to the acquisition of the tramways and their extension. If there is any probability of such acquisition at an early date, it would be worth while to consider how far the proposed electric light station and installation could be modified so as to assist in traction purposes. Tramway work under conditions that could easily be designed and with a quick service, ought not to cost more than horse traction. This may be gathered

from the last report of the Birmingham tramways, although therein it is shown that electric traction cost them about sixpence per car mile more than horse traction; but we maintain this sixpence would about disappear if the conditions were, as they might be, greatly improved. All information bearing upon this subject is interesting, whether it be in the direction of railroad or tramway traction.

UNAUTHORISED NOMENCLATURE.

Elsewhere we reprint, or partly reprint, an article from our American contemporary the *Electrical World*, written by Mr. A. E. Kennelly. Now, Mr. Kennelly is a clever writer, and he knows it—hence is apt to presume a little more than is good for him, and certainly a little more than is good for the generality of technical students. The ruling powers of the *Electrical World* have placed themselves in an equally false position to that of Mr. Kennelly. Let us in the first place state our grievance, and in the second place state the rule which we think all technical writers and journals should follow. Mr. Kennelly, in the article referred to, has named certain units tentatively "gilbert," "weber," "oersted," and "gauss." He was not the first to use the term "gauss"—that use lies at the door of Prof. S. P. Thompson, who ought to have known better. The rule we think ought to be adopted by anybody desirous of naming a unit would be to bring their suggestion before the notice of some authoritative body representing the profession, and all use of new terms should be rigidly avoided till sanctioned by authority. When once a self-satisfied writer has started upon a voyage of discovering names, he assumes his superiority to all and sundry, and is persistent in advocating what tends more to the ridiculous than to the useful. Every unit is to be named, and the name, according to modern electricians, is to commemorate an individual of historical repute. It has been pointed out long ago that the number of units is limited, and the number of names, if not unlimited, will in the time to come receive additions deserving of longer and greater renown than most of those who have gone before and who have been thus honoured. In ancient days philology played its part in word-formation, and worse things might happen than if electricians should again turn for assistance to philologists; but these views have little to do with our immediate object, which is to enter an emphatic protest against the introduction into any article or book of unauthorised terms. We know at least of one society, all-powerful in its own sphere, that absolutely refuses to admit into its journal any unauthorised new term, or even an unauthorised formula. The society has carefully examined and recognised certain letters used in common formulæ to indicate certain things, and these, and these only, are admissible into papers read before the society or published in its *Transactions*. The result has been satisfactory. In this society, when a paper is read there is no need of explanatory sentences, and no difficulty in ascertaining the interpretation of the author's work. With electricians one introduces the "hop," another the "bot," a third the "gauss," a fourth the "oersted," "gilbert," and "weber," and so the ball goes rolling along till you might as well attempt to understand the ravings of a lunatic as the lucubrations of one of those ready writers. Scientific journals have their duty to perform in this matter, and they should refuse to allow the use of terms not sanctioned by some authoritative body, except, perhaps, as suggestions in correspondence. We intend to follow that plan, and exclude terms not internationally recognised, or sanctioned for the time being by the Institution of Electrical Engineers. The latter body ought to draw up—it started to do so some years ago—a scheme of nomenclature and notation which should guide contributors to its *Proceedings*. If the English Institution will not prepare a scheme we trust the American Association will, and compel its members to fall into line. We have long since given up hopes of English electricians taking an initiative except when the subject is one that appeals to the pockets or the glorification of individuals.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

SHUNTS.

SIR,—For a long time past I have had an uncomfortable feeling of want of accord with the explanation of the various text books as regards shunts. A book much admired in its day—Sabine, 1867—comes correctly, though somewhat inelegantly, to the conclusion that "the current in each of the 'branch circuits' is of the same intensity as it would be were the battery in circuit with that line alone, and that when the resistances of the lines are equal the currents circulating in them will be equal also." That would seem to be clear enough, and so simple as not to be mistaken. It assumes pressure at the ends of each branch equal and constant; hence the current in each branch is indicated by the formula $C = \frac{E}{R \text{ of that branch}}$.

Culley, 1878, defines *shunt* as "a wire connected across the terminals of a coil to divert a portion of the current."

Sabine tells me that the current in one branch is absolutely independent of that in any other branch—and it is; hence it cannot "divert a portion of the current," and Culley is wrong. I am fain to believe, however, that Culley's teaching is the accepted teaching, and Sabine's not so generally accepted, for

Gunn, 1890, says: "It is often desirable to send only part of the total current through a galvanometer. This is done by joining up a wire in multiple arc with the galvanometer, so that the current is broken up before it enters the galvanometer, and part goes through the wire and part through the galvanometer."

That is true; but if Sabine is right—and he is—why, just as much current goes through the galvanometer unshunted as when shunted.

Prof. S. P. Thompson, 1881, says: "Strong currents must not be passed through very sensitive galvanometers, for, even if they are not spoiled, the deflections of the needle will be too large to give accurate measurements. In such cases the galvanometer is used with a *shunt* or coil of wire arranged so that the greater part of the current shall flow through it, and pass the galvanometer by, only a small portion of the current actually traversing the coils of the instrument. The resistance of the shunt must bear a known ratio to the resistance of the instrument, according to the principles laid down about branched circuits."

According to Sabine, this statement is all wrong. Just

as much current goes through the galvanometer coil after as before the fixing of the shunt. The use of the shunt, as it were, only makes room for a proportional increase of current. Now, among this diversity of teaching, what am I to believe? My reading of Ohm's law—which, of course, may be all wrong; but as yet no one has shown me it is so—says that so far as current is concerned every branch circuit is independent of every other branch circuit, provided that pressure is kept constant. None of these teachers mention pressure, or E.M.F., or difference of potential, or whatever they like to call it. They leave me to infer—as I do infer—that in all cases they mean me to understand that pressure is constant; and if that is so, then no putting in of shunts can affect the current in the galvanometer. The formulæ for shunts, and much of the bother about them, is all fudge, and only perplexing to the student. I have spent many hours listening to rigmaroles about shunts, and many more reading about them, only to find I have lived in a fool's paradise, and that it is rubbish to talk about by-paths, or that the shunt takes a part of the current which would otherwise go through the galvanometer. You cannot put more or less current through a galvanometer or any other circuit except in one way—by increasing or decreasing the pressure acting. I am well aware that much that is taught about galvanometers is quite correct. I am merely declaiming at the waste of time and trouble I have undergone to be stuffed with information—principally for passing some examination or other—that turns out to be altogether misleading. I could give you extracts from a lot of other books telling me to use a shunt for fear of melting the galvanometer coils, but each and all attributing the effect to the leading away a part of the current through another path than the coils. Perhaps, Sir, you will put me right if I am wrong, and tell me whether the insertion of a shunt is for the purpose of carrying away, say, overflow current, or whether it merely opens up a new channel in which new current is generated in strict accord with Ohm's law.—Yours, etc.,

H. L.

[Our correspondent has fairly taken our breath away. Here is tilting in real earnest. Has he failed in some examination through some misunderstanding with the examiner? If so, we should advise a course of soothing powder; for kicking against examiners does not pay in the long run. They are like parsons, or the House of Lords, against either of which appeals are rarely or never countenanced. But there is much in what "H. L." says. Yet if we begin to criticise the varied statements in school books, we had better wind up all other business and restrict ourselves to that alone. He may, however, in this case accept as correct Ohm's law, which applies to every circuit, the current in the circuit being according to the formula $C = \frac{E}{R}$, so that if he puts one or one hundred shunts in parallel with the coils of his galvanometer by connecting each branch, say, with the terminals of the galvanometer, so long as the pressure acting between the terminals is constant the current through the coils will be absolutely invariable, and no shunt or by-path will affect it in the slightest. In fact, the paths are not shunts or by-paths—they are new paths, and to produce electrical phenomena in them new current is generated just as Sabine describes.—Ed. *E. E.*]

USE OF CONDENSERS.

Sir,—Our attention has been drawn to a recent issue, in which you give an abstract of a paper read before the American Institute of Electrical Engineers. At the conclusion of this abstract the authors are made to express their opinion that "The experiments with the condensers demonstrate the practicability of their use to diminish the line current in transformer circuits, and points to their more extended use as their manufacture is perfected and cheapened, not only in this, but also in other systems of alternating-current distribution." As the paragraph implies the non-existence of any practical condensers, we ask your permission to point out that we have ourselves been manufacturing condensers (under the Swinburne patents) on a commercial scale for the last two years, principally for Germany, and out of the total number supplied by us only one has been returned broken down. We think, therefore, we are fairly justified in claiming to have solved the problem of condenser manufacture on a commercial scale, price being, of course, merely a matter of demand. The Stanley condensers used in these tests were made with waxed paper, a method discarded by us several years ago as quite useless for practical engineering work.—Yours, etc.,

Swinburne and Co., Limited.

Teddington, December 13, 1893.

LIGHTNING EXPRESS SERVICE.

Sir,—I notice in your issue of the 8th instant a small paragraph headed "Lightning Expresses Unbearable," in which you say that it seems another point adverse to my proposal that the physical strain upon drivers and stokers of high-speed trains in the United States is very considerable. Allow me to observe that the natural conclusion to be drawn from this phenomenon appears to me exactly the opposite. If the strain had been so severe on the *passengers* as to tell on *their* health there might be something in the argument, but it is the peculiar nature of the work to be performed by an engine driver travelling on a locomotive at such a high speed which creates the objectional results you mention; and as in my proposed lightning express service there are no engine drivers or stokers, the only objectionable class of work is eliminated, and it renders the service quite possible without injury to the health of the officials of the train. The electrician who works the train instead of the engine-driver will have no harder work at the speed of 150 miles than at 30 miles an hour, and will not be exposed to any of the influences which certainly must render the occupation of an engine-driver under such circumstances absolutely unbearable.—Yours, etc.

T. Behr.

10, Drapers'-gardens, E.C., December 12, 1893.

[We presume that Mr. Behr has someone to take charge of his express service—call him by what name he pleases, and the responsibility involved by 150 miles per hour will not fail to have its effect on nervous systems. We again reiterate our statement that Mr. Behr's plan is neither desirable nor practicable. It will be sufficient for us to prove our thesis when he asks for public money. Up to that point he can argue as much and as long as he likes.

We do not suppose any person ever pays attention to the flapping of the wings of our bantam contemporary, that seems to imagine snarling is sense; choleraic writing, knowledge; and whose office is like that of the stage puppet, to dance to those who pull the strings. We might suggest that too much of silly inanities is calculated to madden all concerned therein.—Ed. *E. E.*]

LIEGE-HERSTAL TRAMWAY.

Sir,—We noticed the account which appeared in your paper dated December 1st, 1893, concerning the Liège-Herstal electric tramway, and read same with great interest. May we take the liberty of bringing to your notice that not all the statements contained therein are quite correct. In particular we beg to point out to you that the two dynamos—each of same is giving 100 amperes at 550 volts at a speed of 700 revolutions—are not made, as you say, by the Allgemeine Elektricitäts Gesellschaft, of Berlin, but by our company. We may say that the former firm has not taken any part whatever in this undertaking and in the supply of any machinery for same.

The fact is that our firm, on taking the entire temporary responsibility for the perfect working of the Liège Herstal electric tramway, concluded the contract with the Société des Tramways Liègeois. We calculated the project, executed it, and put up the whole plant, having constructed ourselves in our works at Liège all the electrical machinery included therein. You would oblige us, therefore, by making a statement to this effect in one of your next numbers.

We profit of this occasion to draw your attention to another very important electrical plant put up by our firm—we mean the transmission of power and electric lighting installation in the Fabrique Nationale d'armes de guerre at Herstal. The electromotive power for the

working of all the machines and machine tools, as well as the lighting by electricity of the whole establishment, is obtained there by our multipolar dynamo—type H. Pieper—of 500 h.p., coupled direct to a Corliss compound engine of the same force.

Beginning of this year the plant has been enlarged by another of our dynamos—type H. Pieper—of 300 h.p., coupled direct to a Willans of the same power.—Yours, etc.,

COMPAGNIE INTERNATIONALE D'ELECTRICITE
(H. Pieper, jun., Director).

Liège, December 12, 1893.

CROMPTON-BRUNTON ALTERNATOR.

Although Messrs. Crompton and Co.'s name has hitherto been chiefly known in connection with the supply of

Fig. 1.

direct-current machinery, they have always had a full appreciation of the advantages of the high-pressure alternate-current system for all work where the distribution has to be carried out over widely-

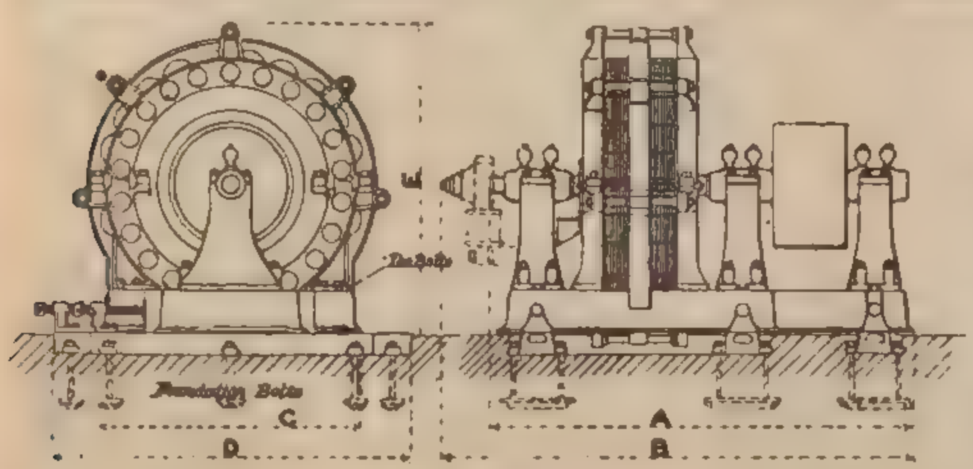


Fig. 2.

scattered districts where the lamp density is too low to pay for the larger amount of copper required for a direct system, and they have in carrying out many of their contracts, where the conditions warranted it, made use of the alternate-current system. They have for some time past occupied themselves in working out a complete system of alternate current machinery, and they believe that they have, while proceeding on well-tried lines, by a careful attention to proportions and mechanical details succeeded in turning out designs which will in practice prove thoroughly reliable and extremely efficient. The most important item of such a system is of course the alternator, and we illustrate below a 60-kilowatt machine, Fig. 1. These alternators have revolving armatures and stationary field magnets. This choice has only been made after careful consideration and considerable experience with both types. Special attention has been paid in this machine to the following points: (1) a ready access to the armature, for inspection or repair, by opening one or both upper halves of the field magnets which are hinged for that purpose; (2) facilities for easily removing and securely replacing armature coils; (3) the provision of a powerful magnetic field and small armature reaction, so that the alternators shall require but little variation of exciting current to suit variation of load; (4) high efficiency, both at full and light loads. The high efficiency has been obtained by the provision of an armature without any iron core, also by the reduction of the power required for the excitation of the field to a minimum, and also by the use of a light revolving armature giving a minimum of weight and loss of power at the bearings, and, as a consequence—not the least importance—a minimum of trouble. The armature is of the well-known disc pattern formed of sector-shaped coils fixed round a periphery of the hub. Probably the parent design of this type of armature is that described in Siemens's original specification of 1878; such an armature is, electrically, probably the best that could be devised, and it is only in the constructional details and proportions that improvements are to be looked for. The special features of the armature as constructed by Messrs. Crompton and Co. are the methods adopted for attaching each armature coil to the centre disc, or hub, and the provision made for drawing it radially inwards toward the centre, so that the whole armature when mounted can be very securely tightened up, thus entirely preventing all detrimental vibration of the armature conductor, and making a very strong and rigid job. Moreover, a new armature coil can be quickly inserted at any time and tightly drawn into place. The field magnets, bearings, and other portions of the machine are of the usual type, and call for no description. The collector is entirely enclosed, to prevent all risk from accidental contact, and the brushes are in duplicate, so arranged that either may be removed for inspection when the machine is at work. The machine illustrated is designed to work at an E.M.F. of 2,000 volts at 600 revolutions, and it has been in almost daily use for the past eight months. It has been frequently run for experimental purposes (with increased speed and excitation) at over 3,500 volts. The power required for the excitation of the field at full load is only 1½ per cent. (750 watts), and the commercial efficiency exceeds 91 per cent. Messrs. Crompton and Co.'s standard sizes of these alternators range from 15 kilowatts to 200 kilowatts, those from 65 kilowatts upwards being provided with three bearings, as shown in Fig. 2.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE VI

(Continued from page 5[illegible].)

Formula for Flow of Gas in Pipes.—Let P_1 P_2 be the initial and terminal pressures in a main of length L (foot units). The velocity of flow is given by the equation†:

$$u_1 = \sqrt{\left\{\frac{g\,c\,T\,m}{\zeta\,L}\;\frac{P_1^2 - P_2^2}{P_1^2}\right\}}$$

where u_1 is the velocity at the inlet of the pipe. For pipes of circular section and diameter d, $m = d/4$. For lighting gas, $c = 130$; for Dowson gas, $c = 64$. Let the temperature be 60deg. F., or the absolute temperature T = 521deg. Then c T = 67,730 for lighting gas, and = 33,344 for Dowson gas. ζ, the coefficient of friction, = 0·005. Introducing the numerical quantities:

For lighting gas—

$$u_1 = \sqrt{\left\{181{,}700{,}000\,\frac{d}{L}\,\frac{p_1^2 - p_2^2}{p_1^2}\right\}}$$

For Dowson gas—

$$u_1 = \sqrt{\left\{89{,}450{,}000\,\frac{d}{L}\,\frac{p_1^2 - p_2^2}{p_1^2}\right\}},$$

where the pressures are in pounds per square inch. When the initial velocity of flow is given, and the terminal pressure is required in terms of the initial pressure:

For lighting gas—

$$p_2 = p_1\sqrt{\left\{1 - \frac{u_1^2\,L}{181{,}700{,}000\,d}\right\}}.$$

For Dowson gas—

$$p_2 = p_1\sqrt{\left\{1 - \frac{u_1^2\,L}{89{,}450{,}000\,d}\right\}}.$$

Case I.—In an ordinary gas distribution the difference of pressure producing flow is small, being about 2½in. of water. If p_2 = 14·7lb. per square inch, p_1 = 14·7361, and

$$\frac{p_1^2 - p_2^2}{p_1^2} = 0·00506,$$

the equations reduce to

$$u_1 = 959·4\sqrt{\frac{d}{L}}\text{ for lighting gas,}$$

$$= 673·2\sqrt{\frac{d}{L}}\text{ for Dowson gas.}$$

The quantity of gas delivered in cubic feet per hour will be $3{,}600 \times \frac{\pi}{4}\,d^2\,u_1$. Assume a distribution to a distance of 5,000ft. Then with the given pressure difference of 2½in. of water column, the quantities of gas discharged and its equivalent in power will be as follows:

A.—LIGHTING GAS.

Diameter of main in inches.	Initial velocity in main. Feet per second.	Cubic feet of gas delivered per hour.	H.P. at 26·5 cubic feet per h.p. hour.
6	9·59	6,782	256
12	13·57	38,350	1,447
24	19·19	217,100	8,189
36	23·50	598,000	[illegible]
	B.—DOWSON GAS.		
6	6·73	4,758	53*
12	9·52	26,910	299*
24	13·46	152,300	1,692*
36	16·48	419,600	4,662*

* Horse-power at 90 cubic feet per horse-power hour.

It will be seen that none of the velocities under this pressure are excessive. The Dowson gas being heavier, the friction is greater and the quantity flowing is less. Farther, as the heat value of Dowson gas is less than that of lighting gas, the amount of power transmitted in a main of given size is only about one-fifth as much for Dowson gas as for lighting gas.

Case II.—It may next be enquired what would be the result of using greater pressure to force the gas through the mains than is usual in supply for lighting. In ordinary gas mains it is found inadvisable to increase pressure because of the increase of leakage. In the distribution of gas for power purposes, this objection would have less weight. The network of mains would be simpler, and the consumers being fewer, there would be fewer joints and valves to cause leakage. By the adoption of some really efficient joint like that used in the Paris air mains, leakage could be almost reduced to zero. The pressure which would then seem to be desirable for a gas power distribution is the pressure which would produce in the mains the highest desirable velocity of flow. It may be taken from the analogy of compressed air mains that 45ft. per second is a quite unobjectionable velocity. Assuming this velocity as the initial velocity in the mains, the problem is to find the necessary initial pressure. The equations become—

$$p_1 = \frac{p_2}{\sqrt{\left\{1 - \frac{L}{89{,}730\,d}\right\}}}$$

for lighting gas, and

$$p_1 = \frac{p_2}{\sqrt{\left\{1 - \frac{L}{44{,}180\,d}\right\}}}$$

for Dowson gas.

For a transmission to a distance of 5,000ft. we get the following results:

A.—LIGHTING GAS.

Diameter of main in inches.	Initial velocity. Feet per second.	Initial absolute pressure lbs. per sq. inch.	Difference of pressure producing flow. Inches of water.	Quantity of gas. Cubic feet per hour.	H.P. transmitted.
6	45	15·59	24·6	31,800	1,200
12		15·12	14·4	127,500	4,199
24		14·0	5·5	509,000	19,210
36	–	14·84	3·9	1,145,000	43,200
		B.—DOWSON GAS.			
6	45	16·70	55·4	31,800	353
12	—	15·64	26·0	127,000	1,413
24	–	15·15	12·4	509,000	5,655
36	—	15·09	8·3	1,145,000	12,722

ELECTRICAL TRANSMISSION OF POWER.

In 1877, Dr. William Siemens indicated the practicability and the probable commercial importance of the electrical transmission of power to considerable distances. In an address to the Iron and Steel Institute he stated that a copper rod 3in. in diameter would transmit 1,000 h.p. a distance of 30 miles. Later, in 1883, he delivered a lecture at the Institution of Civil Engineers on the electrical transmission and storage of power. But he was able to describe as practically working transmissions little else than the Lichterfelde and Portrush railways. Deprez had at that time experimentally transmitted 3 h.p. 25 miles, through ordinary telegraph wires at 2,000 volts, obtaining a return of 32 per cent. only of the energy expended.

It has from that time been hoped that one of the largest fields for electrical enterprise would be, to use the title of Sir W. Siemens's lecture, the transmission and storage of power. Countless predictions have been made in electrical journals that some advance in invention had been accomplished which would revolutionise the conditions of the use of motive power. In these lectures it is necessary to keep to the stable ground of achieved results, and, regarding these alone, the conclusion is unavoidable that the amount of electrical distribution of power actually in operation up to the present time is really comparatively small. Two years ago, Mr. Kapp gave some interesting lectures on the electric transmission of power. In those lectures he describes only a single case of electrical transmission of any magnitude which was then in operation. That was the installation at Schaffhausen, where about 500 h.p. was being electrically transmitted across the river. Since then the striking Frankfort-Lauffen experiment has been carried out, and power transmitted successfully, and without more than about 25 per cent. loss, a distance of 108 miles. High-tension continuous currents from dynamos in series have been used in two or three cases for transmissions to distances up to 28 kilometres. The synchronous alternating method is in operation at Telluride, Colorado, but over a short distance, and in favourable circumstances; but when all such cases have been taken into the reckoning the aggregate power at present transmitted electrically is not very great.

No doubt electrical transmission of power to great distances is possible by more than one method. It is a condition in such a case that a very high tension, 20,000 to 40,000 volts or more, should be used, or the cost is excessive. That such currents will be used seems likely, but can hardly yet be reckoned as accomplished, at least on a large scale, and with commercial success.

In a great deal that has been said about the electrical distribution of power one thing has been forgotten. It is that there have always been means of transmitting power to considerable distances, and if such transmissions are rare, it is not because they would fail mechanically, but because the cost of transmission is too great for profitable application of the power. Motive power was transmitted four miles by compressed air in 1861, before electric transmission was thought of. If electrical transmission is to play an important part it will only be when it can be carried out so cheaply that the power can be supplied to consumers at a cheaper rate than they can manufacture it for themselves.

In the distribution of electrical energy from central stations for lighting purposes a great deal has already been accomplished. Financially, electric lighting operations appears also to be

* Howard Lectures delivered before the Society of Arts.

† Unwin. "Distribution of Power by Compressed Air." *Proceedings*, Institution Civil Engineers, vol. cv.

succeeding, though it is too early to estimate the measure of their success. But a higher price will be paid for energy for lighting than for energy required for power. In towns like Geneva, where electricity can be generated by cheap water power, and where gas costs 7s. per 1,000 cubic feet, the success of electric lighting is assured. In other cases the great convenience of the electric light will no doubt counterbalance some excess of cost when compared with other means of lighting.

In one other case, which is strictly a case of power distribution from a central station, electrical engineers have achieved a remarkable success. In the United States there are now some 4,000 or 5,000 miles of electric tramways, which are working with complete mechanical success. It does not appear that the cost of electric traction is much lower than the cost of horse traction. For one of the oldest and best managed tramways, the West End Street Railway of Boston, the working cost of traction has been given at 22 cents per car mile for electrical traction, and 24 cents per car mile for horse traction, the earnings per car mile being about the same in both cases. But the electric cars attain speeds of 10 to 15 miles an hour, and in American towns, with wide spreading suburbs, they have great advantages. Almost with no exception—probably the Budapest tramways are the only important exception—the electric tramways which are in successful operation have cheap overhead conductors carried on posts. Such a system is not suitable for European towns, and with more expensive methods of carrying the conductors the success of electrical traction is at least more doubtful.

A case where electricity is likely to be used very successfully in transmitting motive power is in working traffic on underground and overhead railways. When passenger trains have to be run at short intervals on a line with numerous stations, electric motors distributed over many carriage axles have great advantages, besides freedom from smoke and steam. It is possible that, even in working cost, the electric motor will be superior to the steam locomotive. But this, again, is a case where cost of power is not a governing consideration, or where, at least, a considerable price can be paid for power.

For both lighting purposes and traction purposes a high price can be paid for power. But when power is distributed for industrial purposes, the question of cost is much more important, and the progress of electrical methods of distribution has been much less rapid. Every electric lighting company would be glad to supply power, if only to increase the day load and so to reduce the idle time of the machines, and in a very few cases power is taken from electric lighting mains. Mr. Shoolbred has stated that in Bradford a few electric motors for hoists, lathes, and other purposes have been fixed. But at 6d. a unit the cost per effective horse power is £60 per annum (3,000 hours). At that rate the power can hardly be used except for occasionally-worked or intermittent machines. Even if electricity were sold for power purposes at half the price charged for lighting the cost of the power would be greater than that of steam or gas power.

(*To be continued.*)

THE FUTURE OF ELECTRIC RAILWAYS.

A lecture was delivered on Monday before a crowded audience, in the Chemical Theatre of the Owens College, by Dr. Edward Hopkinson on the subject of electric railways.

Dr. Hopkinson, after a reference to the extent to which electricity is now used for traction purposes, directed attention to the essential features common to all electrical tramways or railways, illustrating his remarks by some interesting experiments with a number of working models. With regard to the electric railway running underground in London, Dr. Hopkinson stated that since the opening of the line the locomotives had run 1,300,000 miles, and a traffic of 18,000,000 passengers had been provided for. Already five schemes had been authorised by Parliament for similar railways in London alone, and Paris, Brussels, Vienna, and Berlin were considering similar undertakings. Concerning the best means of producing the electrical power, he had to say that here, at any rate, in England this, as for electric lighting, was dependent upon the economical production of steam power; but there were essential points of difference between the conditions under which steam power was required for electric traction purposes and for electric lighting. In Scotland and Ireland, however, and many countries abroad, particularly in Switzerland and Italy, there was abundant water power, now only very partially utilised, which might be easily rendered available for working electric railways. Some instructive details were then given of the comparative cost of electric and steam power. The City and South London line had, he said, enabled experiments to be made on the efficiency of the railway system as a whole, taking into account the loss of power in the generators, on the line, and in the motors, and in the resistances of the locomotives. The loss in the line was about 11 per cent. of the electrical power generated, and the efficiency of the locomotives as a whole was 70 per cent.; thus the electrical efficiency of the entire system was 62 per cent. The trains weighed, with full load of 100 passengers, about 40 tons, and the average speed between stations was 13.5 miles per hour. The cost of working, including all charges, during the last half year was 6½d. per train mile. It was perhaps hardly a fair comparison to compare the cost of working such a line as the South London line with the cost of steam traction on other lines, inasmuch as steam could not possibly be used in the tunnels, only 10ft. 6in. diameter, in which this line was constructed, but the comparison was not uninstructive. Take the Mersey Railway, where the gradients and nature of the traffic were similar. On the Mersey Railway the locomotives weighed about 70 tons, and the train, which was capable of carrying about 350 passengers, 150 tons. According to the published returns of the company, the cost of locomotive power is 14d. per train mile—i.e., more than double the cost on the South London line, but for a train weighing between four and five times as much, but capable of carrying only three and a half times the number of passengers; thus the cost of steam traction per ton mile of train was about half that per ton mile of train for electric traction. But it was not on the cost per ton mile that the success of a passenger line depended. The real basis of comparison was the cost per passenger mile, and here electric traction had great advantage over steam, as the dead-weight of the electric motor was small compared with the dead weight of steam locomotives of the same power; and with electric motors the trains could be split up into smaller units at but slightly increased cost, so permitting a more frequent service. We could not expect, therefore, that electric traction, with our present knowledge, would take the place of steam traction on our trunk lines; but it had its proper function in the working of the underground lines now projected for London, Paris, Berlin, Brussels, and other large towns, and also, he thought, on other urban lines; for example, on the Liverpool Overhead Railway, where trains of large carrying capacity were not required but a frequent service was essential; and finally, also, on those short lines, whether independent or branches of the great trunk lines, where water power was available. When he undertook the construction of the Bessbrook line it was a condition that the cost of working should be less than the cost of working by steam, a condition which the first six months of working showed to be successfully fulfilled. When Messrs. Mather and Platt undertook the construction of the electric plant for the City and South London Railway they guaranteed that the cost of traction for a service of 8,247 miles per week, as actually run, should not exceed 8½d. per train mile. Their anticipations had been more than realised, the actual cost being now 6½d. per train mile only. There were, however, other projects, both in America and on the Continent, for electric railways on which the special feature was to be an enormously high speed of travel, speeds of 150 and even 200 miles per hour being promised. With a steam locomotive, involving the reciprocating motion of the piston and connecting rod, such speeds were probably unattainable, but they might be realised in the purely rotary motion of an electric motor. But at such high speeds as these, the power required to overcome the air resistance was of special consideration. Assuming, however, that the ordinary laws of air resistance hold good, he calculated that the power required to propel an ordinary train 200ft. long at 200 miles per hour against the resistance of air alone, apart from the frictional resistances, would not be less than 1,700 h.p. Though there was nothing to prevent the construction of electric locomotives capable of developing this, or even greater power, the strength of the materials at present at command would set a limit to the speeds which may be obtained. If, however, modern civilisation required a speed of travel of over 200 miles per hour, he ventured to predict that it would be more efficiently realised by regarding it as a problem in projectiles and not of ordinary locomotion. In conclusion, Dr. Hopkinson pointed out how Joule's researches had prepared the way for the great developments of electrical engineering at the present day. Thus they realised, said he, why it should be, and why, as he believed, it was, that here in Manchester Joule was honoured, and his name and work familiar to not only men of science, but to every intelligent employer, every foreman or draughtsman—nay, every 'prentice boy engaged in the vast circle of engineering industries of which Manchester was the centre.—*Manchester Guardian.*

LEGAL INTELLIGENCE.

STRICK v. LATIMER CLARK, MUIRHEAD, AND CO., LIMITED.

This case was heard before Mr. Justice Wills on Tuesday in the Queen's Bench Division. It was a claim for commission.

Mr. J. W. McCarthy appeared for the plaintiff, and Mr. Lockwood, Q.C., and Mr. Pollard for the defendants.

According to the plaintiff's case, the defendants requested him in 1889 to introduce them to certain persons who were about to acquire parliamentary powers for establishing a system of electric lighting in certain areas of the city of Westminster and the defendants promised the plaintiff that if he obtained for them the introduction, and if, in consequence, the defendants secured a contract

or did business with the persons mentioned, the defendants would pay the plaintiff a commission. In February or March, 1889, the plaintiff introduced the defendants to Mr Browne Martin, the chairman of the Westminster Electric Supply Corporation, and that introduction resulted in a contract on December 5, 1889, by which the corporation agreed to do certain works for not less than £100,000. The plaintiff claimed £1,000 commission. The defendants denied there was an introduction by the plaintiff, and further, that if any commission was due the amount claimed was excessive, as the contract of December 5 was not definite, and in fact, an action had been brought on it, and after being heard for two days before Mr. Justice Hawkins and a special jury in May, 1891, a settlement had been arrived at by which the defendants accepted £4,000 in satisfaction of all claims and costs. The defendants further contended that they had always been ready to give some gratuity to the plaintiff for obtaining the signature of Mr Browne Martin to a document, and they paid £40 into court in satisfaction of all claims.

Evidence was given on both sides, and much correspondence between the parties read.

Mr Justice Wills, in giving judgment, said that in cases of this kind, where there was a conflict of testimony about conversations, there could be no better way of getting at what actually took place than by looking at the correspondence. Here the plaintiff had claimed commission from the first. It was remarkable that if the Board, composed of the defendants, had always taken the view that no commission was due, and £40 was to be the only remuneration, nothing appeared to that effect on the correspondence. He thought the plaintiff was entitled to a commission as the introducer of a gentleman with whom the defendants afterwards did business. The only question was how much. It was understood that the amount was to depend on the business ultimately obtained. There was no principle on which the amount of commission in this case could be calculated, but, having regard to the settlement of the action before Mr. Justice Hawkins for £4,000, he thought £300 would be a proper amount to allow the plaintiff.

Judgment was given for the plaintiff for £260 beyond the £40 paid into court.

COMPANIES' MEETINGS.

GENERAL ELECTRIC POWER AND TRACTION COMPANY, LIMITED.

Directors: The Earl of Albemarle, K.C.M.G., A.D.C. (chairman), Lord Egerton of Tatton, Moritz Immisch, Esq., Sir Henry C. Mance, C.I.E., Thomas Parker, Esq., M.Inst.C.E., James Pender, Esq., J.P.

Report of the Directors submitted to the shareholders at the third ordinary general meeting held at Winchester House, E.C., on December 12, 1893.

The Directors beg to submit the balance sheet and profit and loss account for the year ended 30th September, 1893. At the last annual meeting the shareholders were informed that arrangements had been made with the Electric Construction Company, Limited, by which that company undertook the management of the affairs of this Company. The Directors have pleasure in stating that this arrangement has worked very satisfactorily, and the following comparative figures indicate the economies which have been effected in the management. The trading accounts for the past year show a profit on the manufacturing department of £1,010. 12s., and a profit on launch department of £31. 14s. 2d., whereas for the previous year the accounts showed losses of £3,121. 14s. 2d., and £570. 10s. 3d. respectively. Furthermore, the expenses of management, exclusive of Directors' fees have been reduced from £3,727. 15s. 5d. in 1892, to £556. 17s. 2d. in the past year. The Directors have decided to cancel the amount of £862. 10s. standing to their credit at the end of September, 1892, and have debited the past year with only £186. 18s. in respect of remuneration. During the past year the Directors have determined sundry unprofitable transactions by sales and closing of leases, and have made provision for possible depreciation on such of the dismantled plant as is still unsold. The accounts, however, do not deal with the larger question, raised by the auditors in their report of January last, whether the book value of patents and goodwill should be further reduced. The Directors regard it desirable that the capital should be brought into conformity with the real position of affairs, and they are giving this matter their further consideration with a view to a reorganisation of the Company. The question of removing the manufacturing works referred to in the last report has received the anxious consideration of the Directors, and, with the assistance of the new management, they hope to overcome this difficulty in a way which offers many advantages over the original plan of removing the works to Millwall. An agreement has been made, subject to the approval of the shareholders, for an amalgamation with the Acme Electric Works at Kentish Town. This arrangement has the merit of providing suitable manufacturing works already equipped at a smaller annual cost for rent and other standing charges than that at present incurred by the Company, and avoids the heavy cost of removing machinery to a distance, and the serious disorganisation of the current business which this would involve. The copper depositing works at Millwall are now completed, and the question of providing the necessary capital for commencing operations is receiving the consideration of the Directors. In accordance with the articles of association, Mr. *Moritz Immisch and* Mr. James Pender retire by rotation, and offer themselves for re-election. The auditors, Messrs. Ward and Wilding, also retire, and offer themselves for re-election.

PROFIT AND LOSS ACCOUNT.—Showing Transactions of the Year ended Sept. 30, 1893.

Trading Account.—Manufacturing Department.

Dr.	£	s.	d.
Salaries and commission	621	4	2
Rent, rates, taxes, fire insurance, gas, etc.	711	11	10
Advertising, printing, postages, stationery, carriage and general trade expenses	905	0	4
Balance, being profit carried down	1,010	12	0
	£3,248	8	4

Cr.	£	s.	d.
Gross profit on manufacturing account	3,248	8	4
	£3,248	8	4

Trading Account.—Launch Department.

Dr.	£	s.	d.
Wages of men, salaries of staffs, and captains of boats	1,494	18	0
Coal and coke	204	6	7
Advertising	250	1	4
Sundry trade expenses	136	5	2
Travelling expenses, etc.	95	0	7
Printing, postages, etc.	96	4	10
Rent, rates, taxes, and fire insurance	223	18	2
Lock dues, survey and registration fees	144	10	9
Balance, being profit carried down	31	14	2
	£2,677	1	7

Cr.	£	s.	d.
Hires, charging, and profit on sale of boat	2,677	1	7
	£2,677	1	7

General Profit and Loss Account.

Dr.	£	s.	d.
Directors' fees	186	18	0
Rent	176	15	1
Management expenses	556	17	2
General expenses, printing, etc.	207	10	11
Maintenance of patents	39	3	10
Maintenance of plant and launches	554	3	1
	£1,721	8	1

Cr.	£	s.	d.
Manufacturing department, profit as above	1,010	12	0
Launch department, profit as above	31	14	2
Transfer fees		16	0
Loss transferred to balance sheet	678	5	11
	£1,721	8	1

PROFIT AND LOSS ACCOUNT, No. 2.—Showing Liquidation of Old Transactions.

Dr.	£	s.	d.
Depreciation of plant at Barking, Chertsey, Kentish Town, and of launches on Lake Windermere and Manchester Ship Canal	5,784	7	3
Expenses connected with up keep of Barking, Windermere, and Manchester plants, including sums paid for determining leases at Windermere, and removal of Barking plant	572	4	6
Expenditure and book items written off relating to liabilities incurred in former years, and settled or compromised during this year	1,308	12	10
Debtors considered good last year, written off	602	7	6
Reserve against bad and doubtful debts of previous years	451	0	0
	£8,718	12	1

Cr.	£	s.	d.
Amount standing at credit of Directors in last balance sheet, cancelled	862	10	0
Loss, carried to balance sheet	7,856	2	1
	£8,718	12	1

BALANCE-SHEET, SEPT. 30, 1893.

Liabilities.

	£	s.	d.
Authorised capital—			
25,000 ordinary shares of £10 each	250,000	0	0
10,000 preference shares of £10 each	100,000	0	0
	350,000	0	0
Issued capital—			
23,592 ordinary shares fully paid	235,920	0	0
10,000 preference shares £9 called up	90,000	0	0
	325,920	0	0
Plus calls paid in advance	156	0	0
	326,076	0	0
Less calls in arrear	674	0	0
	325,402	0	0
Sundry creditors	7,792	15	5
Reserve for discount and bad and doubtful debts	451	0	0
	£333,645	15	5

Assets.		£ s. d.
Capital expenditure as per last balance sheet . .		219,264 12 4
Balance of purchase of copper depositing patent, subject to contingent claim .		10,000 0 0
Further expenditure on copper depositing works and purchase of plant and new launch built . .		14,304 13 8
		243,569 6 0
Less depreciation, £5,784. 7s. 3d., and sale of plant, £350		6,134 7 3
		237,434 18 9
Stock on hand		14,469 11 11
Sundry debtors		4,716 0 10
Cash at banks and on hand		191 15 11
Profit and loss account as per last balance sheet	£68,299 0 0	
Add balance of profit and loss account, £678. 5s 11d.; and expenditure connected with liquidation of previous year's transactions, £7,856. 2s. 1d. . .	8,534 8 0	
		76,833 8 0
		£333,645 15 5

The third general meeting of this Company was held on Tuesday at Winchestor House, E.C., to receive the report of the Directors and the balance sheet as given in the preceding column, and to consider and, if deemed advisable, to pass the following resolution

"That this meeting approves the agreement submitted to it, made between this Company and a trustee for the Acme and Immisch Electric Works Limited, relating to the sale to the latter company of the Kentish Town branch of this Company's business, and authorises the Directors to carry the same into effect subject to such modifications, if any, as they may determine."

Lord Egerton of Tatton presided, and in moving the adoption of the report and accounts, said that they were drawn up in such a way that the shareholders could clearly see the position of the Company. He was sorry that the general depression of trade still affected the Company, and that in the four branches, which in the first instance there was a good prospect of developing, they had not succeeded as they thought they would do. In the case of electric traction, in consequence of the North Metropolitan Tramways Company not taking up the experiment which they had successfully instituted at Barking, and as the success which they had been able to show there had not been sufficient to induce municipal corporations to undertake electric traction, they had been unable to carry on that work. They would see from the balance sheet that there was a depreciation on account of the Barking plant, which they were now endeavouring to dispose of, and which was at present unprofitable. With regard to launches, there had been a slight profit, but not such as to induce them to go on and increase that branch very largely. There did not seem to be any large demand for that class of business, and he thought it would be wise if they could profitably dispose of that plant, and be able to concentrate their operations on the manufacturing business and upon the copper depositing branch There was a loss on the general balance sheet, but, on the other hand they had very much diminished the expenses of management, which had been undertaken by the Electric Construction Company, who, as preference shareholders were largely interested in the Company. They had struck off £802 as Directors fees and the latter for the present year had been reduced to the very lowest amount. With regard to the manufacturing works, it was necessary to leave, owing to the termination of the lease. There was an idea, mentioned in the last report, of transferring the Kentish Town works to Millwall, but that would have been a very costly removal. The Directors had therefore decided to recommend to the shareholders an amalgamation with the Acme Works, whose establishment was in close proximity and was well equipped with suitable machinery for the manufacture of electrical apparatus, and the plant would be transferred there The Directors considered it desirable that this amalgamation should have effect by the formation of a new company, to be called the Acme and Immisch Electric Works, and it was proposed that the new works should be managed as the Company was now namely, by the Electric Construction Company in order to save the expense of a separate staff, and by that means a great deal of the subsidiary work that the Electric Construction Company now performed could be carried out, and the works be fully employed at a very much less cost than if a separate management existed. The terms of the amalgamation were based upon the relative value of the two works, in which the Company would receive five eighths and the Acme Company three eighths of the capital. It was proposed that the capital should be £25,000 of which £20,000 would be in fully paid ordinary shares in the proportion mentioned and it would require £5,000 in preference shares as working capital. The copper depositing works at Millwall had been finished but the state of the copper trade, which was in a very different position to what it was when the works were commenced, had rendered it a question as to how far it would be profitable to start them at the present time They were waiting for a favourable opportunity, and were considering the matter of providing the necessary capital for beginning operations as soon as the market was in a favourable condition for them to do so With regard to the general position of the Company, it was quite evident that under present circumstances the capital of the Company was not fully represented by its assets, and that there was a debit balance against it of £76,000. It was quite clear that some reorganisation of the Company would have to be undertaken. At present the preference shareholders would have the first claim upon any profits made upon the present capital The present was certainly not a favourable time for starting any new commercial transactions, and therefore, although the general policy of the Board had been to endeavour to reduce the expenses and to try to dispose under as favourable circumstances as possible of the existing works which they had which had in previous times been a source of loss, they were sensible that a general scheme of reconstruction must before long be carried, and they were giving the matter serious consideration When a proposal was ready, they would call the shareholders together and submit it to them.

Mr Moritz Immisch seconded the motion for the adoption of the report and accounts.

A **Shareholder** enquired about the manufacturing department, and upon what the profits were made. It seemed to him that they were very much at the end of their tether.

Another **Shareholder**, who complained of the bad management of the launches on the Thames, asked whether it was not possible to arrange for the launches not to be taken further away than the storage permitted? The launches had a bad name on the Thames, and had sometimes to be towed back.

Mr. E. Garcke, in explaining the position of the Company, said that the Electric Construction Company simply took up the position of managers of this Company The result of that had been a decided economy in expenses His time had been largely engaged in liquidating and closing up transactions which in the opinion of the Board it was undesirable to carry on. With regard to manufacturing operations, at the time the Company was formed it took over the business of Immisch and Co., who made motors and other electrical apparatus. That business had not been quite as satisfactory as it was, and it had been their desire to work it up again, and this amalgamation would have the effect of reviving the former credit of Immisch and Co. as makers of motors, dynamos, and other apparatus. That profit which was shown in the first portion of statement No 1. had been made entirely on manufacturing and contracting. There had been a loss in that department in previous years, but this year it was on the right side With regard to the position of the ordinary shareholders in respect to the proposed amalgamation, the proposition was to form a new company, and to transfer the manufacturing business of the General Electric Power Company to that company, receiving in consideration fully paid up shares in the new company. It was the new company which would issue preference shares, and the shareholders in this company would be in the same position as before. Until some reorganisation or reconstruction of the Company was carried out, the position of the shareholders would undergo no change. The formation of the new company would have the advantage that, whereas at present the manufacturing works of the General Electric Power Company could not be carried on by reason of the lease expiring, by the amalgamation they would be able to obtain suitable works and machinery without any outlay of capital He admitted in a large measure the justice of the remarks concerning the bad management in the past of the electric launches They had, however, done better on the Thames this year, and in order to put that department on a satisfactory footing some new arrangement would be necessary.

The motion for the adoption of the report and accounts was then put and carried unanimously

The retiring directors were then re-elected and the auditors were reappointed

The **Chairman** then put the resolution proposing the amalgamation, and after some discussion it was adopted.

HOVE ELECTRIC LIGHTING COMPANY.

The first annual general meeting of this Company took place at Hove on Tuesday. The chairman, Colonel A. J. Filgate, R.E., presided The Directors' report was given in our last issue.

The **Chairman**, in proposing the adoption of the report and balance sheet, pointed out that up to September 30 the Company had issued 3,290 shares, producing £16,450; that on that date they were in debt to their bankers to the extent of £2,500 on account of a loan guaranteed by the Directors, and that their other liabilities amounted to over £8,500, the bulk of which was due to the contractors Against those liabilities they had the value of the actual work executed in the temporary and permanent generating stations, mains, plant, etc., £24,761, cost of meters, £583; office furniture, £69, and outlay on preliminary expenses and installation suspense account, £908 The revenue account up to September 30 showed a debit balance of £264 10s., and considering the small demand during the early months of the Company's operations that must be deemed satisfactory On July 1 they had 52 houses connected with the system, representing 3,778 33-watt lamps; at the end of September the houses supplied had increased to 72, and the 33-watt lamps to 5,478, and at the present date they had 86 houses and were supplying the equivalent of 6,225 33-watt lamps. Agreements had been signed for 14 additional houses which would shortly be connected with their system, and from enquiries they had received they believed that number would soon be considerably increased They understood that the Hove Commissioners were about to extend the light to the Town Hall, and they hoped the lighting of some portions of the town with arc lamps would soon be put in hand On the whole, there was every probability of the demand for the current being largely increased at an early date Owing to the comparatively small amount of capital they had been able to raise up to the present time, the Directors had not

had an easy time, but they trusted the shareholders would be satisfied with what they had done and the position which the enterprise had attained. But for the action of the contractors in carrying out the work of their contract largely in excess of the amounts for which the Company were able to pay, they could not have attained that position. The capital needed for the construction of the first portion of the mains and the temporary generating station was, as they were aware, found by the Directors and their friends, and no appeal was made to the public for subscriptions until after the supply of electricity was commenced. He was sorry to say the appeal then made did not produce the amount of capital they anticipated, nor did a second appeal made in the spring of the year. Being, however, fully satisfied with the progress made in the demand for electricity in Hove, and believing in the ultimate financial success of the undertaking, the Directors and Messrs. Crompton and Co. determined to do all in their power to push on with the work and fulfil the contract with the Commissioners. A main item in the contract was the erection of a permanent generating station, and as the demand for electricity was steadily increasing, it became apparent that in addition to the contract obligation of the Company, the increased power provided by the permanent plant would soon be needed to meet the requirements of the public. Under these circumstances, the Directors obtained a temporary loan of £5,000 on their personal security, to be devoted to the construction of the permanent generating station and electrical works, and the result was that those works were now approaching completion and would, they hoped, soon be brought into use. In the meantime, the demand for the electric current had so rapidly increased, while the days were also becoming shorter, that they were obliged to increase the temporary plant to ensure the demand being satisfied. The work the Company was doing in supplying electricity was largely in excess of what it was ever anticipated the temporary plant would be called upon to perform. Over six miles of mains had been laid, and more would have been put down but for a difficulty experienced in getting a sufficient supply of the Crompton Davis castings, which had to be used in the places where, owing to the position of the cellars, they were unable to construct concrete culverts. Their general policy in constructing mains was to tap the streets most likely to yield customers for the current—a policy which had been approved by the Commissioners, and one which they intended to adhere to as far as possible. From an approximate account of the working of the Company each week since July 1, he said that while in the earlier weeks the accounts showed a loss, that loss gradually diminished until near the end of September when the returns commenced to show a profit, which had steadily increased since, and he thought it might be safely anticipated that the accounts for the half-year ending December 31 would show some profit after meeting all administration and other charges. This was a result which must be considered as highly satisfactory for the second half year in the life of a new enterprise, working under considerable difficulties and with temporary machinery and plant. Having devoted a considerable amount of time to looking into the affairs of the Company, he believed it was likely to prove a financial success. Their progress was distinctly more rapid than he had anticipated, and everything pointed to its continuing. Their undertaking was a local one, and so far as he could gather their reputation was good, and it was generally believed that the Company would be a remunerative investment. Notwithstanding these favourable circumstances, their appeals to the public of Hove had not met with the response they hoped to obtain, but he was fully aware that the present year had been about the worst on record for investments, and that the public were very much averse to putting their money into anything but what were called "gilt-edged" securities. They had no hesitation in recommending their enterprise to the people of Hove, and hoped they would soon supply the necessary capital to complete it. He had been informed some misunderstanding existed as to the probability of their Company yielding good dividends, based apparently on the stipulations contained in the provisional order of the Board of Trade of 1890, that any excess of revenue after meeting certain charges and paying 5 per cent. on the capital invested in the electrical works should be utilised in reducing the authorised charges for electricity. But in the deed transferring this order to their Company, which deed had been approved by the Board of Trade, it was specially provided that the clause of the provisional order was not applicable to the Company. Further, it was provided that no charge could be required from the Company in their schedule of charges during the first seven years of their existence. After that period the Hove Commissioners could only move the Board of Trade to reduce their scale of charges if the Company, in the seven years preceding, should have earned such a profit as would enable them to pay dividends at the rate of 10 per cent. per annum for the whole of such period. The Chairman concluded by expressing the satisfaction of the Directors with the excellent way in which the works had been carried out by Messrs. Crompton and Co. and their staff; their thanks to their own staff, and to the Hove Commissioners and their staff for the assistance they had always afforded, and especially to the chairman of the Commissioners, Mr. Woodruff, for the cordial support he had given the undertaking and the interest he had taken in it.

Mr. Carleton E. Tufnell, who seconded the adoption of the report and balance-sheet, was supported by **Mr. R. E. Crompton**, who joined in the appeal of the chairman to the inhabitants to make the undertaking a local one. They wanted local support, and the money paid by the users of the light to be a source of income to the residents of Hove themselves. Speaking of the *generating* plant, Mr. Crompton said the design was the latest, *and would work most* economically. The works' cost had been reduced to a certain figure per unit, 3·3 lower than had ever been accomplished before for the same outlay. The more widely the remarkable results of the enterprise so far were ventilated the better for the Company, which wished to increase their capital to complete their works, and for the users of the light, because cheap manufacture meant cheap prices eventually.

On the motion being put, it was unanimously adopted.

BUSINESS NOTES.

Birmingham.—The electric light has been introduced in the Art Gallery.

Lanner.—The lighting of Lanner is occupying the attention several of the leading parishioners.

Western and Brazilian Telegraph Company.—The receipts for the week ended December 8 were £3,453.

Twickenham.—It has been decided for the present not to proceed further with the proposed electric light scheme.

Globe Telegraph and Trust.—The directors have declared an interim dividend of 1s. 3d. per share, payable on the 18th prox.

Liverpool Overhead Railway Company.—The traffic receipts of this railway for the week ending 10th inst. amounted to £686.

Canterbury.—The name of Alderman Mount has been added to the members of the Electric Lighting Committee of the Town Council.

Newport (Mon.).—The tenders for the electric lighting plant for the municipal station will probably be given out on the 21st inst.

West India and Panama Telegraph Company.—The receipts for the two weeks ended November 30 were £2 less than for the corresponding period.

Ulverston.—The Health Committee of the Local Board have passed a plan of a new boiler house and electric lighting house for Messrs. Pollitt and Co.

Porthcawl.—The Local Board have decided to accept the tender of the Porthcawl Electric Company to erect 23 lights and maintain them at £2. 10s. per annum.

Swansea.—A Swansea councillor is reported to have a scheme in his mind for lighting Swansea Docks and Harbour by means of a dynamo and a waterwheel.

Penistone.—The clerk stated at a meeting of the Local Board that he had written to the Sheffield Electric Lighting Company for certain particulars, but they were referred to the Brush Electric Company.

Gilsland Spa Company.—This Company has been registered with a capital of £15,000 in £10 shares to adopt a certain agreement, and to carry on the business of hotelkeepers and suppliers of gas and electricity.

Aberdare.—The Local Board have received an application from Messrs. Gery and Rhys asking the Board to assent to the lighting of the town by electricity. The question is to be discussed at the first meeting in January.

Incandescent Lamps Wanted.—Mr. E. C. Trevor Roper, of Okehampton, has written to a provincial contemporary asking where incandescent lamps can be obtained at 1s. 6d. each, "probably only serviceable for 100 hours."

The Charge of Forgery.—Mr. Henry Everard Hunt, manager of the Taunton Electric Light Works, has been committed for trial on charges of forging and uttering two promissory notes for £233 and £44, with intent to defraud.

Eastern Extension Company.—The Eastern Extension, Australasia, and China Telegraph Company, Limited, have declared an interim dividend for the quarter ended September 30 of 2s. 6d. per share, tax free, payable on January 16.

Belfast.—Queen's Quay is now lighted by the electric light. At a social gathering in connection with the fire brigade last week, it was mentioned that Mr. J. H. Greenhill had carried out the electric lighting of the fire brigade buildings.

Leamington.—The sub-committee appointed to consider the advisability of lighting the parish church by electricity has submitted a report recommending that an installation should be put down, at a cost not exceeding £280. This report has been adopted.

Blackburn.—In proposing the adoption of the minutes of the Gas Committee of the Town Council, Alderman W. Thompson withdrew all the clauses relating to the question of electric lighting, for the further consideration of which he proposed to again call the committee together.

Taunton.—The Town Council on Tuesday adopted a report of the Electric Lighting Committee recommending that the various courts in the town should be lighted by incandescent lamps, and that the town be lit by electricity until dawn, instead of leaving the streets in darkness at 3 a.m.

Islington.—The Vestry have adopted a resolution instructing the Electric Lighting Committee to consider whether any part of the works in connection with the generating station in Eden-grove can be satisfactorily carried out by the Vestry itself, without the intervention of a contractor.

Lynton.—The Lighting Committee of the Local Board having reported on the advisability of having an ornamental iron pillar at the cost of about £20, on which to put an arc light, the committee have been requested to reconsider the matter, as in the opinion of the Board the work could be done equally well at a less cost.

Rotherham.—The town clerk announces that the borough of Rotherham require a teacher to conduct a class in theoretical and practical chemistry, two nights per week, at the School of Science and Art, Rotherham. Applications to be sent to Mr. H. H. Hickmott, town clerk, Council Hall, Rotherham, not later than the 18th inst.

Halifax.—A special meeting of the Council is to be held to consider a recommendation of the Gasworks and Electric Lighting Committee that the proposed central electric lighting station should be erected on land belonging to the Corporation situated on the south side of King street, and not on the gasworks land, as previously selected.

National Telephone Company, Limited.—The directors of this Company have declared interim dividends for the half year ending October 31, 1893, as follows. On first and second preference shares at the rate of 6 per cent. per annum, less income tax; on third preference and ordinary shares at the rate of 5 per cent. per annum, less income tax.

Commercial Cable.—The Commercial Cable Company has determined to redeem on the 15th January next the whole of the outstanding mortgage debentures of the Company, being 800 debentures of £100 each, and notifies that the principal sums will be payable at the offices, 12, Queen Anne's gate, S.W., of Messrs. Siemens Bros. and Co., Limited.

Folkestone.—The Town Council have received a letter from the Borough Association stating that the members desired to strengthen the hands of the Corporation, in order that they might retain the power of providing electric light for themselves, and not part with it to a private company. The report of the Electric Light Committee is not yet ready.

Dudley.—Alderman Bagott mentioned at a meeting of the Town Council that it was desirable to show the Council and the town that the Streets and Gas Committee were looking after their interests in the matter of the electric light. It was, however, not desirable that they should spend some thousands of pounds for an order, and then not be able to go on with it.

Venezuela Telephone and Electrical Appliance Company, Limited. Messrs. E. D. Oppert and Co. have this week offered for sale £50,000 of 5 per cent. first mortgage debentures of £100 each at the price of £87½ per cent., repayable at par on October 1, 1910, or at the Company's option any time after July 1, 1895, at £105, upon six months' notice of redemption.

Coventry.—The Town Council have passed the minutes of the General Works Committee referring to a letter of objection addressed by the town clerk to the Board of Trade with respect to the proposed transfer of the undertaking of the Coventry and District Tramways Company to the Coventry Electric Tramways, Limited, and to correspondence thereon between the town clerk, the Board of Trade, and Mr. Graff Baker.

Electric Drilling and Riveting Machines.—The Thames Ironworks and Shipbuilding Company have acquired the sole right of manufacture for the United Kingdom of Mr. F. J. Rowan's electric magnetic drilling, riveting, and caulking machines, which have already met with much favour among shipbuilders and bridge builders. In portability and convenience of handling these machines are claimed to be much superior to hydraulic tools.

Partnership.—As will be seen from our advertisement columns, an old established firm of manufacturing electrical engineers is desirous of arranging for the admission to partnership of an electrician, or a pupil who has just finished his apprenticeship. He will be required to take control of special branch, and introduce £2,500 for the extension of it. Applications to be sent by letter to "Chartered Accountant," care of Bates, Hendy, and Co., 37, Walbrook, E.C.

Monmouth.—Mr. Edwards asked, at a meeting of the Town Council last week, whether steam or gas would be used as the motive power for the new system of drainage. The Mayor calculated they would not want to put down motive power for 12 months after the granting of the loan. By that time he hoped to have a provisional order for the electric lighting. The Town Council on Tuesday approved a memorial to the Board of Trade asking for a provisional order for lighting the borough by electricity.

Tenders for Harrogate.—It will be seen from our advertisement columns that the Corporation of Harrogate invite tenders for concentric insulated cables for high-pressure distribution. Specifications may be obtained on application to Mr. Samuel Stead, borough surveyor, Municipal Offices, Harrogate on payment of £1. 1s., which sum will be returned on receipt of a *bonâ fide* tender. Sealed tenders, endorsed "Cables," must be addressed to the chairman of the Electric Lighting Committee, and are to be sent in to the town clerk's office by the 30th inst.

City and South London Railway.—The employés of Mr. John Talbot, contractor, who have been engaged on the recently completed extension contract at Stockwell terminus for this Company, through the combined generosity of Mr. Talbot and the Company, have been entertained at dinner at the White Bear Tavern, Kennington Park road. The receipts of the Company for the week ending December 10 were £911, against £933 for the same period last year, or a decrease of £22. The total receipts for the second half year of 1893 show an increase of £158 over those for the corresponding period of 1892.

Electric Construction Company, Limited.—At a meeting of this Company, held at the offices, Queen street chambers, Queen street, E.C., last week the resolutions passed on the 16th ult., altering the articles of association, were confirmed. The directors notify that, in accordance with the deed of trust dated August 16, 1893, various numbers of debentures to the amount of £2,060, for payment at par on January 1 next were on the 8th inst. publicly drawn at the offices of the Electric and General Investment Company, Limited (the trustees), in the presence of Mr. C. J. Watts, notary public.

Swan United Electric Light Company.—The accounts of this Company for the year ending September 30, 1893, have been before the directors, and, subject to audit, they have resolved to recommend the shareholders to declare a dividend as follows: 3s. 6d. per share on the 78,949 ordinary shares of the Company, £3 10s. paid, and 4s. 3d. per share on the 19,750 £5 fully paid shares, free of income tax. This, together with the interim dividend paid on June 20 last, will make a total distribution of 7½ per cent. for the year on the ordinary £3 10s. paid shares of the Company. The warrants will be issued on the 23rd inst.

Aberystwyth.—On the recommendation of the Main Roads Committee, the Cardiganshire County Council agreed on Tuesday to allow the Bourne and Grant Electricity Supply Company to lay their electric light mains along the main road from Capel Bangor to Aberystwyth, subject to the work being done as directed by the county surveyor, and to the deposit by the company of the sum of £50 with the county treasurer to cover any cost the county may incur in restoring the surface of the road and making good any damage done in the carrying out of the works, and subject also to an annual payment of 5s. for the easement.

Newcastle.—The City Lighting Committee have arranged, with regard to the electric lamps at the top of Grey street, that a survey should be made of the same at the beginning of the new year, with a view to effecting still further improvements in that particular part of the city. An order has been given for a lamp to be erected in Raby street, Byker. The new hall which has been erected in Northumberland road, and to which the name "Olympia" has been given is lighted by means of hundreds of electric lamps and gas lights. The electric light fittings, etc., have been supplied by Messrs. Parsons and Co.

Dover Electricity Supply Company.—The subscription list of this Company, which is being formed with a capital of £50,000, closes to-morrow. The capital is made up of 10,000 shares of £5 each. The sum of 10s. per share is payable on application, 10s. on allotment, and the remaining £4 will be called up as required, in sums of not more than £1 per share at intervals of not less than two months. Prospectuses and forms of application for shares can be obtained at the bankers, the National Provincial Bank of England, Dover and London, and at the offices of the Company, 49, Queen Victoria street, London, E.C.

Abergavenny.—When the Improvement Commissioners discussed the question of gas lighting last week, Mr. Jenkins said that one thing which had struck him was the number of places where they were going in for the electric light, and as long as the Gas Committee was not able to do anything until next spring, it was a matter which he thought they ought to give attention to, and make enquiries in that direction. Personally, he was opposed to the electric light, but they could not shut their eyes to the fact that in many places they were putting in large and costly installations. The committee should make some enquiries on the matter.

Burton-on-Trent.—The Town Council have adopted the report of the Gas and Electric Light Committee which contained several recommendations for increased lighting accommodation, chiefly in Horninglow and Winshill. Various works, estimated to cost £100, were stated to be necessary at the electric light depot, and permission for their execution was granted. In moving the adoption of the report, Alderman Lowe said that the electric light works were making good progress, and that Mr. Ramsden, the gas manager, hoped to have the new illuminant ready for the use of the public by the end of January. So far, they had not received a great number of applications.

Bootle.—When the minutes of the proceedings of the Finance Committee of the Town Council were moved on Wednesday, Councillor Quayle asked if something could not be done about lighting the Town Hall with electricity. When there was a bazaar, a concert, or public meeting in the hall they found that the ventilation was not so good as was desirable, and he thought that with the new light, which would not cost very much, a great improvement would be noticeable. Councillor Swyny said that the subject of electric lighting was under the consideration of the committee, and no doubt he would be able to give the Council more information upon it at a future date.

Portsmouth.—The Town Council have referred to a committee a resolution that the Town Hall clock tower should be illuminated nightly within one hour of sunrise. The clock is wired for electric lighting. The Electric Lighting Committee at a meeting a few days ago, submitted certificates from Messrs. Waller and Manville for payment to the contractor for buildings of £300; to the contractors for boilers, engines and electrical plant, £4,000; and to the contractors for conduits etc., £2,000. The amounts were ordered to be paid by the Council. A sum of £500 was also ordered to be paid to the engineers (Messrs. Garnett, Waller, and Manville), on further account of their commission, making with previous payments of £200 and £300, two thirds of the commission agreed to be paid.

Lighting in Westminster.—The Highways Committee of the London County Council reported on Tuesday that they had considered two notices from the Westminster Electric Supply Corporation of intention to lay mains in various streets. The committee recommended that the sanction of the Council be given to the works referred to on condition that the company give two days' notice to the Council's engineer before commencing the work; that the mains be laid under the footways wherever it is found prac-

ticable to do; that before any street boxes are constructed the designs for, and the proposed positions of, them shall be submitted to and approved by the Council's engineer, and that the covers thereof shall consist of iron frames filled in with materials to suit the paving.

St. James's and Pall Mall Company.—Lords Justices Lindley, Smith, and Davey, sitting in the Court of Appeal, last week heard the appeal of the St. James's and Pall Mall Electric Light Company, Limited, against the decision of Mr. Justice Kekewich, who held that the plaintiffs in the action of Fry and Francis v. the St. James's and Pall Mall Electric Light Company, Limited, were entitled as holders of founders' shares in the Company, to have paid to them one half of two sums of £1,000 set aside by the directors as a redemption fund. Their Lordships held that half of the profits above a specified amount went to the holders of the founders' shares, and the £2,000 set apart was included in "profits" to which they were entitled. The appeal was dismissed, with costs.

London County Council Inspector.—The Highways Committee of the London County Council reported on Tuesday that the Council on November 3, 1891, appointed Mr. A. E. Rossiter, on probation for 12 months, at a salary of £200 a year to discharge the duties of an inspector under the Electric Lighting Acts. When the time came for the confirmation of the appointment, the committee were not in a position to judge fully Mr. Rossiter's qualifications for the post, and on their recommendation the Council, on November 15, 1892, extended the period of probation for another year. The committee have now satisfied themselves of Mr. Rossiter's ability to discharge the duties devolving upon him, and recommended that the appointment of Mr. A. E. Rossiter should be confirmed.

The Ealing Tenders.—The following is a list of the tenders received by the Ealing Local Board for the building of the engine and boiler house, etc., at the central station:

Wilkinson Bros., Finsbury Park (accepted)	£7,381	0	0
H. Vernon, Dewey lane, Derby	7,610	6	10
J. Dorey and Co., Brentford	7,900	0	0
J. Allen and Sons, Palmerston Works, Kilburn, N.	8,426	13	0
W. H. Lorden and Son, 107, Trinity road, Upper Tooting	8,461	0	0
S. and W. Patterson, 5, Whitehall, London, S.W.	8,584	0	0
J. Mowlem and Co., Grosvenor Wharf, Westminster	8,662	0	0
W. Gibbin and Son, 21 to 24, Pickering place, Bayswater	9,780	0	1½

Electric Lighting at Bristol.—The Town Council on Tuesday discussed the subject of electric lighting. It was announced that in the cost of building the central lighting station alone, the original estimate had been exceeded by no less than £19,000, chiefly owing to the heavy cost of piling the foundations. A local paper states that it had always been understood both by the Electric Lighting Committee and the public generally, that if at any future time it was desired to extend the light farther than the present experimental area, all that would be necessary would be to lay new mains in the districts proposed to be so lighted. It was, however, mentioned at the meeting that if they desired to extend the light, not only would new mains have to be laid, but the whole of the mains already laid would have to be taken up and relaid.

Grimsby.—A meeting of the Public Lighting Committee of the Corporation has been held to consider the provisional order for electric lighting, a copy of which had been supplied to each member. In reply to a question the Town Clerk said the period in which the works were to be carried out was two years although they had hoped for three years. This was, however, the usual order made by the Board of Trade, but they could get the time extended if necessary. Mr. Connell moved, and Mr. Grainger seconded, that the Council be recommended to approve the order. The Mayor expressed the hope that if they found the electric light would be an advantage, before the expiration of two years they would be supplying it to the town. He remarked that many large shopkeepers had expressed a wish to have the light. The resolution was adopted unanimously.

Richmond Sewerage Works.—The contract for the lighting of the Richmond main sewerage works, Mortlake, which was entrusted to Messrs. Drake and Gorham, has now been completed, and the trial run of 12 hours of the whole plant with all the lights on proved very successful. There are 56 8 c.p., 16 c.p. and 32 c.p. lamps for general purposes, four 300 c.p. lamps for lighting the engine room, and a 400 c.p. lamp has been fixed for the outside tanks. As a considerable amount of moisture is always present in the well and mixing room special precautions have been taken to prevent any possible leakage. A supper was given on the 4th inst. on the formal taking over of the installation when testimony was borne as to the amicable understanding existing among all concerned during the carrying out of the work. Mr. A. H. Preece was retained as consulting engineer and Mr. Fairley, the engineer to the Board, supervised the work generally.

Bradford.—A scheme is on foot for the introduction of electric cooking ovens into Bradford, and a sample oven has been sent by a Birmingham firm of makers to Mr. Baynes the manager of the Corporation Electricity Works, for exhibition. Mr. Baynes has handed the oven over to Mr. J. Bentley, of the Bradford Coffee Tavern Company, who is making arrangements for a thorough test of the apparatus at the Exchange Café, Market street. The oven is of the Crompton type. Alderman Moulson (chairman of the Gas and Electricity Supply Committee), in moving on Tuesday the adoption of the minutes of the committee, said that he and the deputy chairman had been to Huddersfield to visit the gas and electricity works in that town. The electricity works were on a larger scale than those at Bradford, and had been built upon a site better suited for such a purpose than the land possessed by the Bradford Corporation at Bolton road. The Huddersfield works were capable of being extended as found desirable.

Lighting of Harrogate.—A Local Government enquiry is to be held for obtaining sanction to loans for the various works to be undertaken by the Corporation, including sewage disposal, baths extension, street improvement, electric lighting, etc. The engineer's plan for the suggested modification of the compulsory electric lighting area has been approved, and the town clerk has been instructed to forward the same to the Board of Trade, and ask for approval. It has been resolved that the buildings and plant for the electric light shall be erected on a site on the Corporation farm, near the Skipton road. The electrical engineer (Mr. Wilkinson) has been instructed to complete his detailed report on the installation. At a recent meeting, Mr. Meyer moved an amendment that the question of the destructor be not entertained. The Mayor seconded and contended that it would be folly to add a refuse destructor to the electric lighting plant, as they would be adding extra cost to a scheme which he was afraid would be a burden. Mr. Ward contended the scheme would be of great advantage to the town, and he was supported by Mr. Simpson. It was decided by 12 votes to 4 to adopt a refuse destructor, and also that the site should be on the side of the farm near Skipton road.

The Newport (Mon.) Tenders.—The following is a list of the tenders received for the erection of the buildings and foundations for the machinery for the municipal electricity works of the Corporation:

W. Gradwell, Cardiff, and Barrow-in-Furness (accepted)	£4,750	0	0
J. H. Firbank, Newport	5,080	0	0
T. Evans, Cardiff	5,243	10	6
A. S. Morgan and Co., Newport	5,250	0	0
W. Lissaman, Limited, Mickleton	5,320	0	0
W. Price, Newport	5,334	0	0
J. Francis and Son, Newport	5,380	0	0
A. E. and J. D. Parfitt, Newport	5,455	0	0
H. C. Parfitt, Newport	5,500	0	0
G. Geen, Newport	5,618	0	0
C. H. Reed, Newport	5,984	0	0
Paragon Patent Roofing Company, Smethwick, glazing only	92	0	0

No less than 52 separate tenders for the supply of electric plant had been received, and these have been referred to Mr. Hammond for his examination and comparison.

Glasgow.—The Lord Provost, in a review of the past year's work of the Corporation, mentioned last week that the third branch of work that the Watching and Lighting Committee had in hand was the lighting of the city. Here the feature of the year had been the introduction of electricity as a street illuminant. Since the current was switched on the main arteries of traffic in the central area of the city had been lighted by that agent, and now electric light pillars were being erected along the main thoroughfare of Argyll street and Trongate from the site of the old Gushet House, Anderston, to the Cross. With regard to the gas and electric lighting department, two important works had been completed during the year. The new electric light station in Waterloo street was opened on February 25 last. This station was designed for the supply of electricity within the central area of the city and the building and plant originally put down, including the street mains, had cost about £80,000. The plant at first put down was to supply about 12,000 lamps of 8 c.p., but so great had been the demand that as many as 15,000 lamps of 8 c.p. had been supplied, while the number of consumers was still increasing, and the committee had had to give authority to the electrical engineer to lay down additional distributing mains, engines, boilers, and dynamos.

Stafford.—An enquiry was held on Wednesday by Colonel W. M. Ducat, R.E., respecting the application of the Corporation to the Local Government Board to borrow £20,000 for the purpose of electric lighting, and £2,000 for the purpose of extending the accommodation of the public baths. The town clerk, Mr. M. F. Blakiston, explained that the Corporation obtained powers in 1890 to supply the electric light, but no further steps had been taken, as it was found that there was no immediate demand for the light. At the end, however, of 1892 the County Council applied to the Corporation for a supply of electric light to the new hall which they were erecting. This would give them a good customer for about 500 lights, and he had no doubt that others would soon follow when they could get started. An estimate for the cost of an installation for immediate requirements had been made by Mr. J. F. Bell, the gas engineer, and approved by Dr. Hopkinson, of London, at £12,000. It was, however, thought advisable, in view of the very probable extension which would be required, to provide for this, and they therefore asked for a loan of £20,000. Dr. Hopkinson thought that the extension indicated would be required during the first year. He felt confident that a profit could be made from the works. The inspector subsequently visited the site of the proposed electric light works.

Walsall.—The General Purposes Committee of the Town Council have recommended the adoption of a report of the Electric Lighting Sub-Committee, and application to the Board of Trade for their approval of the adoption of a system of electric lighting for the borough on the principle suggested in the report, viz., high tension, with transformers. They also recommended that application should be made to the Local Government Board for their sanction to a loan of £19,650, in addition to the suggested site at

the Wolverhampton street Gasworks, for the cost of carrying out the proposed scheme, and that contracts should be made as follows, as soon as the sanction and approval of the central authorities had been obtained viz., with the Electric Construction Company for the electrical plant, for £10,093; with Messrs. Bumsted and Chandler for the engines, for £1,350; and with Messrs. H and T Danks for the boilers, for £805. The Mayor, in explanation of the position of the Council in this matter, said if the Corporation did not at once do this work a private body could come in by the authority of the Legislature and undertake it. The committee had given the most careful attention to the question of electric lighting, and he was satisfied that the installation they proposed was not going to do much injury to the gas undertaking. The report has been adopted.

Lighting at Bolton. The Gas and Electricity Committee of the Corporation have fixed Wednesday next for the ceremony of laying the corner-stone of the electricity buildings on Spa road, Alderman Miles, J.P., having been requested to officiate. The tenders for the work are considerably below the original estimate of £18,132 for the scheme at present in contemplation, but the addition of another engine and alternator will bring the cost up £21 295, and this plant, it is expected, will be adequate to supply the borough with electricity for some years. The excavating and foundation laying has been well advanced, and during the progress of this work a spring of water has been discovered which will prove of much value to the department, it being intended to use this water for supplying the boilers. The dimensions of the engine room and boiler house are 83ft. 6in. by 46ft., and the total frontage of the offices is 80ft. The building work is being pushed on as speedily as possible under the supervision of Messrs. Hinnell and Murphy, architects, and the putting down of plant and laying of mains, which will be done under the direct personal superintendence of Mr. J. H. Rider, M.I.E.E., electrical engineer to the Corporation, will be commenced forthwith. As some misunderstanding exists locally as to the nature of the charges to be made for the supply of electricity, a table has been drawn up by the engineer to make this matter clear.

Traction at Cork. At a meeting last week of the Standing Committee of the Corporation a letter was read from Messrs. J. W. Bourke and W. B. Ronan. The writers stated that they "send you the resolution of the Corporation as to the use of electricity, which the directors wish to have altered as we have amended same, making the working of the tramcars by electricity or horse power optional as desired by the promoters. Please get amendments passed at the next meeting of the Standing Committee, and confirmed at the meeting of the Council on Friday next." Alderman Crean said that they objected before, and they would object again, to having overhead wires through the city. Mr. Gutman said the overhead wires were already passed. The Chairman said that it was found impracticable to work the underground wires. The overhead wires would be placed 24ft. from the ground, which would ensure safety. Alderman Crean said that overhead wires were not allowed in any city in the kingdom, and he did not see why they should be allowed there. The Chairman said that several cities had been mentioned to them in which overhead wires were allowed. Mr. Rahilly said that he did not see why there could be any objection to that portion of the scheme. Alderman Hungerford proposed that the amendment be made. Mr. Rahilly seconded the proposition, and it was passed.

Plymouth. At a meeting of the Town Council on Monday, Mr. Jinkin moved, and Mr. Kerswell seconded, a resolution approving of the resolution passed some little time since sanctioning an application to the Board of Trade for a provisional order authorising the Council to supply electricity for public and private purposes within the borough. Mr. Pethick suggested whether some amicable arrangement could not be made with the gas company, who were also seeking parliamentary power for electric lighting. Mr. Bond pointed out that the gas company had long had notice of the intention of the Council, and as the matter concerned a monopoly in which the convenience, comfort, and lighting of the town were involved, he hoped the Council would go on with their own proposal, irrespective of any other. Mr. Harvey asked if the adoption of the resolution would commit the Council to a large expenditure. In the tramways they had quite sufficient unremunerative enterprise. The Town Clerk said the resolution was necessary if the Council wished to have powers to supply the electric light. The cost of an unopposed electric lighting order was about £160. The gas company's Bill was brought forward after the Council had given notice of its intention to apply for electric lighting power, and it seemed to be promoted with the object of securing for the gas company a monopoly of the supply of light to the town. Replying to Mr. Pethick, the Town Clerk said if the gas company opposed the application of the Council for an electric lighting order they would not succeed in their opposition. On a poll being taken 30 members voted for the resolution, and none against, the remainder abstaining.

Lighting at Wolverhampton. A report has been presented to the Town Council by the Lighting Committee with regard to the scheme for supplying the electric light to the town. Originally a tender by the Electrical Construction Corporation to lay down the plant for a sum of £25 772 10s. was submitted for approval, but since the appointment of Mr. F. H. Lewis as electrical engineer to the Corporation, the scheme has been revised with a view to subdividing the contract. It is now proposed to provide a generating station in Commercial road, from which the electrical energy will be transmitted to a central station at the Town Hall. From this central station the high pressure current will pass to various substations in the compulsory area, which will be at the Art Gallery, Free Library, and Town Hall, where it will be transformed into low-pressure energy for distribution. The total amount of the new tenders, plus £1 320 estimated for arc lamps, is £18,762 14s. 2d., as against £25,772 in the original estimate. Other items of necessary expenditure will reach £4,020, and the total amount of capital expenditure for which a loan is sought will be as follows: Plant, £17,442 14s.; arc lamps, etc., £1 320; other capital items, £4,020; cost of buildings and contingencies, £7,228 5s.; total £30,011. The Mayor, in moving the adoption of the report on Monday, said with regard to the estimated cost of buildings and contingencies, that the plans had been issued, and the tenders would shortly be laid before the Council. The Lighting Committee were anxious to push the scheme on and to obtain the approval of the Board of Trade and the Local Government Board; but before this could be secured certain figures would have to be forwarded to the central authorities, in order that an inspector might be appointed to make enquiry into the matter. It was intended to apply for power to borrow £30,000 to carry out the scheme, but it was not intended to expend the amount at once. Alderman W. H. Jones seconded the motion, which was agreed to.

Electric Lighting at Chatsworth. A complete system of electric lighting has been carried out at Chatsworth House, the Derbyshire residence of the Duke and Duchess of Devonshire. All the rooms in the mansion that are being used have been fitted with the electric light in place of candles, which have hitherto been used. There are installed 850 incandescent lamps, ranging in candle power from 6 to 50. Between 40 and 50 men have been constantly employed on the work, which has been carried out in the absence of the Duke and Duchess, and when all the power is turned on the mansion is a blaze of light, which is rendered soft and subdued by means of tinted shades and various newly designed patents. This installation is of interest as showing the extent to which natural forces can be utilised for the generation of electricity. At a height of some 400ft. above Chatsworth House there exists a lake of some nine acres in extent, to which a pipe was laid some years ago for the purpose of supplying water to the well-known Emperor fountain. Mr. Drake, the electrical engineer, found that by tapping this pipe he could obtain as much as 150 h.p., or sufficient for all the lighting required. In the general arrangement of the lighting Mr. Drake's object has been to utilise all the handsome old fittings, for which purpose a special imitation electric candle has been introduced. This so nearly resembles wax in colour that it is impossible to distinguish the two when placed side by side. Where fittings have been added the style of each room has been carefully studied, and the fittings have been made to harmonise with the architectural requirements. In many of the rooms, such as the oakroom, where metal work would have been out of place, the lamps have been skilfully embedded in oak carving, worked on to the original panels, by which arrangement the lamps are almost invisible in the daytime. The installation has been designed and carried out by Mr. Bernard Drake, of Messrs. Drake and Gorham, 66, Victoria street, Westminster, with the assistance of the estate staff, working under the direction of Mr. Martin, the agent, and Mr. Woodhead, the clerk of the works.

Lighting of Camberwell. -The Vestry last week considered a proposal for applying for a provisional order. When the matter was brought forward, Mr. Phillips moved that the seal of the Vestry should be affixed to a memorial to the Board of Trade for a provisional order under the Electric Lighting Acts to supply electricity for public and private purposes in the parish. The speaker drew attention to Bradford, a town which more than any other could be likened unto Camberwell. In Bradford they supplied an area of 120 acres; in Camberwell they proposed to supply something less than 60 acres. In the former place they had 20 miles of mains, but they proposed to start with only 4½ miles of mains. Bradford supplied with electricity 26,263 lamps of 8 c.p., and in 12 months they produced 401,540 units. They charged 5d. per unit for lighting and 4½d. for motive power. The cost of production was 3·0910 pence, and they made a profit of £3,000 a year. In Bradford their capital was £48,880. In Huddersfield they sold electricity at 6d. per unit and it cost them 3d. per unit. After quoting statistics regarding other towns, he said he thought he had shown conclusively that what they required could be obtained for £50,000. He thought they could save a large amount upon the destruction of the last. He did not think, like Mr. Manville, that they could consume their dust without coal. He believed, however, they could dispose of at least 8,000 loads of dust at a saving of £1 000 a year. They were not asking that night to spend £50,000, it was only something like £100. They had already spent £100, and he felt sure that another £100 would enable them to secure the provisional order. Mr. Ben Ellis seconded the motion. Mr. Preston said that if they went into Mr. Philip's statement they would find that there was not the smallest comparison between the towns quoted and Camberwell. Bradford was a manufacturing town and Camberwell was a parish of paupers. He was perfectly willing to have the electric light, but at somebody else's expense, and not at the expense of the ratepayers. Northampton, a town of shoemakers, had been alluded to. There was no comparison in this case, for there he believed electricity was used more for manufacturing purposes than for lighting. All they would do in Camberwell by adopting electric lighting would be to drive a lot of people out of Camberwell because of the heavy rate. He moved the rejection of the motion, and Mr. Logg seconded. He thought they ought to study this dust-destructing business on its merits before they went in for this scheme. They also wanted one necessary thing, and that was the ability of the ratepayers to bear the extra burdens which the scheme might cast upon them. Mr. Perry hoped the Vestry would decide that night that, having spent £100, they had had enough of this business, and drop it. When a tradesman made a bad debt the best

thing to do was to write it off, and he thought they ought to do this with the £100 already spent. This was not an opportune time, and there was no analogy between Camberwell and Bradford. They had no manufactories, and Camberwell was a very straggling district. Mr. Finlay said, as the representative of a very poor district, he could not support this proposal. They should not go away with the idea that they were going to get off with £50,000. When that came to be paid for they would find it was £100,000. Mr. Harbord asked the supporters of this scheme if they were pursuing this policy because there was any demand for it from anybody. There seemed to be no one demanded it but Mr. Phillips, Mr. Parker, and a few others. He knew some electric lighting companies whose £5 shares were being offered at one-eighth of their value. Other companies were actually ashamed to show the figures. He did not think there was any hope that they would ever have a supply of electricity at a profit in Camberwell. Upon a show of hands the Chairman declared the motion rejected. A division was demanded and taken, with the result that the motion was not carried.

PROVISIONAL PATENTS, 1893.

DECEMBER 4.

23231. **Improvements in micro-telephones.** George Lee Anders and Walther Kottgen, 5, Great Tower street, London.

23241. **Improvements in electric storage batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

23253. **Improvements in electric alarms.** John Hutcheson Ballantyne, 115, St. Vincent street, Glasgow.

23283. **Improvements in couplings for connecting together conductors of electricity.** Leonard Penson, 433, Strand, London.

23303. **Improvements in or relating to accumulators.** Alfred Julius Boult, 323, High Holborn, London. (Jean Lecoq, Belgium.)

23304. **Improvements in or relating to arc lamps.** Alfred Julius Boult, 323, High Holborn, London. (Jean Lecoq, Belgium.)

23307. **An improvement in conductors and rubbers for electric railways or tramways.** Fritz Bernhard Behr, 28, Southampton buildings, Chancery lane, London.

23308. **Improvements in continuous-current dynamos, either for generating or for receiving electric currents.** Maurice Hutin and Maurice Leblanc, 28, Southampton-buildings, Chancery-lane, London.

23309. **Improvements in continuous-current dynamos, for either generating or receiving electrical energy.** Maurice Hutin and Maurice Leblanc, 28, Southampton-buildings, Chancery-lane, London.

DECEMBER 5.

23327. **Improvements in electric lamp fittings.** Arthur James Howes, 73, St. Stephen's road, Upton Park, London.

23331. **Improvements in electrical current regulators and electrical heating apparatus.** Samuel Wells Cuttris, The Elmwood Electrical Works, Camp-road, Leeds.

23337. **Improvements in electric motors.** Henry Capel Lofft Holden, Royal Arsenal, Woolwich, London.

[redacted] **Improvements in the manufacture or production of electrodes or plates for batteries, especially secondary batteries.** Herbert Green Spearing, 46, Lincoln's-Inn fields, London.

23366. **Improvements in phonographs.** Henri Jules Lioret, 52, Chancery lane, London.

23385. **A combined ammeter and voltmeter.** Edward W. Jewell and William Zimmerman, Norfolk House, Norfolk street, Strand, London.

23424. **Improvements in incandescent electric lamps.** Henry Green, 45, Southampton buildings, Chancery-lane, London. (Complete specification.)

23436. **Improvements in apparatus for electrolytically producing soda and chlorine.** Henry Harris Lake, 45, Southampton buildings, Chancery lane, London. (The Union Chemical Company, United States.) (Complete specification.)

DECEMBER 6.

[redacted] **The prevention of humming noise of dynamo-electric machines.** Frank Bailey, 17, South-street, Manchester-square, London.

23468. **A method of adapting incandescent electric lamps to table, standard, hanging, and other oil lamps.** Arthur Barton Kent, 47, Lansdowne-gardens, South Lambeth, London.

23472. **Improvements in electrical measuring instruments.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 16, Red Lion-street, Clerkenwell, London.

23477. **Improvements in contacts for electrical signalling.** John Orme, 65, Barbican, London.

23478. **Improvements relating to the electrolytic preparation of oxygen and the halogens and to the simultaneous production of electrodes.** Alfred Coehn, 11, Southampton buildings, Chancery-lane, London.

DECEMBER 7.

23543. **Improvements in or connected with electric arc lamps.** Robert James Canavan, 27, Tavistock-place, Tavistock-square, London.

DECEMBER 8.

23,605. **Improvements in the method of attaching reflectors to electric lamp holders or sockets.** Percy Garnuss Ebbutt and John Benjamin Verity, Plume Works, Aston, Birmingham.

23614. **An improved instrument for controlling the flow of current through electric circuit or circuits.** Philip O'Neal, 191, Hampstead road, London.

23633. **An electric motor designed to drive continuously any clockwork or time-keeping mechanism.** James Parkin, 27, Sandhill, Newcastle on Tyne. (Complete specification.)

23669. **Improvements in electrolytic vessels for primary and secondary batteries or accumulators, and other processes of electrolytic decomposition and electrolytic action, such as for the extraction of metals from their ores, electro-depositions, and the like.** Paul Schoop, 28, Southampton-buildings, Chancery-lane, London.

23673. **Improvements in telephones.** Walker Moseley, 103, King's road, Peckham, London.

23676. **Improvements in and connected with primary batteries, and in safety lamps to be used therewith.** Howard Vivian Coad, 37, Cursitor street, Chancery-lane, London.

23684. **Improvements in connection with the electro-deposition of metals.** Thomas Bradford Bates and Arthur Ewbank Leefe, 55, Chancery lane, London.

23687. **Improvements in telegraphy and in the means employed for perforating tapes used for this purpose.** Patrick Bernard Delany, 24, Southampton-buildings, Chancery-lane, London.

23688. **Improvements in and relating to electric batteries.** Louis Fortoul and Charles Thorye, 45, Southampton-buildings, Chancery-lane, London.

DECEMBER 9.

23733. **Improvements in electrical means for signalling on railways in a fog and at other times.** Illius Augustus Timmis and George Neill Abernethy, 2, Great George street, Westminster, London.

23744. **Improved method of and appliances for lighting railway trains by electricity.** Ridley James Urquhart, 57, Barton arcade, Manchester. (Pascual de Ysasi Yasmendi, Spain.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1889.

15958. **Electric mains, etc.** Engelbach and Bright. (Second edition.)

1890.

20009. **Telephone exchange apparatus.** Kinsbury. (Western Electric Company.) (Second edition.)

1892.

21169. **Electric arc lamps.** Dulait.

23231. **Electric glow lamps.** Scharf.

24122. **Electroliers, pendants, etc.** Bowker.

1893.

813. **Electric accumulators.** Pollak.

1198. **Arc electric lamps.** Brockie.

1951. **Arms for supporting telegraph-pole insulators.** Marsh.

2129. **Mica rings for insulating purposes.** Haddan. (Jefferson).

2703. **Electrical fuses.** Bates.

18066. **Supporters for electric lamps, etc.** Lake. (White.)

19423. **Electric current distributing system.** Von Dolivo-Dobrowolski and others.

19534. **Electric light switches.** Davis.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2⅜
Charing Cross and Strand	—	[illegible]
City of London	—	11½
— Pref.	—	13
Electric Construction	—	1¾
House to House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22¼
Liverpool Electric Supply	6	6⅜
	3½	4⅜
London Electric Supply	5	1
Metropolitan Electric Supply	—	8
National Telephone	5	4⅞
St. James', Pref.	—	8½
Swan United	3½	3⅛
Westminster Electric	—	5¼

NOTES.

Leicester.—The Town Council propose to municipalise the tramways.

Rugby.—It is proposed to establish a telephone exchange at Rugby.

Threats by Telephone.—Threats are now being sent by telephone in Paris by anarchists.

Ayr.—Water power for electric lighting is under the consideration of the Town Commissioners.

Dublin.—It is proposed in March next to construct a double electric tramway between Blackrock and Dublin.

Light Railways. — The Shoreditch Vestry have suggested the construction of light (possibly electric) railways in the metropolis.

Smoking Concert.—The third grand smoking concert of Messrs. S. Z. de Ferranti, Limited, was held on Friday at the Blue Last Tavern, Ludgate-hill.

Geissler Tubes.—A paper on this subject was read a few days ago before the Yorkshire College Society of Chemists and Colourists by Mr. G. Hefford, B.Sc.

King's College School.—The Astronomer Royal, Mr. W. H. M. Christie, distributed, on Tuesday, the annual prizes, etc., gained by pupils at King's College School.

The Brighton-Rottingdean Railway.—The Bill for the laying down of this railway has passed through Parliament, and the necessary capital is said to have been privately subscribed.

The Blackpool Electric Tramway.—As will be seen from another column, Mr. T. Parker and Mr. Holroyd Smith are to overhaul this tramway and the plant, each on his own responsibility.

Royal Institution.—The members of this institution in special general meeting have recorded their deep regret at the death of Dr. John Tyndall, who was for 40 years connected with the institution.

Dowlais.—Differences have occurred between the local authority and the gas company. Feeling runs so high that Councillor Evan Lewis is reported to have declared that if an electric light company were formed, he would subscribe for a thousand pounds' worth of shares.

Civil Engineers.—The council of the Institution of Civil Engineers have recently nominated for election as honorary members the Duke of Devonshire, Dr. Edward Frankland, Captain Sir Douglas Galton, Prof. von Helmholtz, and the Marquis of Salisbury.

Developments in Telephony.—At the last weekly meeting of the Bradford Scientific Association a paper was read by Mr. E. E. Gregory on "Recent Developments in Telephony." The paper was amply illustrated by means of apparatus, diagrams, and lantern slides.

The "Medical Battery" Company, Limited.—Messrs. C. B. Harness, McCully, Hollier, and Towers were again brought up at Marlborough-street on Wednesday. Further evidence was given, and the case again adjourned. The charge against Mr. Towers has been withdrawn.

Faure's Accumulator Patent in Germany.—We understand that the Imperial Court of Appeal at Leipsic has just decided in an action brought by the Hagen Accumulator Company against certain manufacturers of secondary batteries in Germany that the employment of lead in the state of super-oxide, oxide, or insoluble salts as a filling material for accumulator plates comes under Faure's patent.

The Tickers are to Go.—It is understood that the committee of the Stock Exchange have resolved to adopt the views of the sub-committee to whom the question of the use of tape machines was referred for investigation. The sub-committee recommended that the machines giving Stock Exchange quotations should be directly under the control of the committee of the Stock Exchange. This decision is subject to confirmation at the next committee meeting, and if it is finally adopted its effect will be widespread.

Obituary.—We regret to announce the death of Mr. William Wallace Duncan, the well known stock and share broker and tramway expert. The deceased was the author of "Duncan's Tramway Manual," an excellent work on the financial position of English tramways.—The death of Henry Goebel, which has just taken place, removes from the world of electricity a rival of Edison's. Goebel maintained through thick and thin that he, and not Edison, was the real inventor of the incandescent electric lamp, and, as will be remembered, he did not hesitate to carry his case into a court of law.

Purification of Sewage.—M. Hermite, whose electrical process for the purification of sewage was referred to in our last issue, in connection with the experiments undertaken by the municipalities of Havre and Lorient in dealing with sewage by electrolysed sea-water, visited Worthing on Saturday to make arrangements for a series of experiments. M. Hermite was accompanied by Mr. Cooper, the electrical engineer who has been associated with M. Hermite in the work abroad. The spot selected as the scene of operations was West-street, close to the sea. The experiments will shortly be commenced.

Crystal Palace School of Engineering.—On Wednesday, Mr. A. R. Binnie, chief engineer to the London County Council, distributed the certificates gained by students of the school of engineering during the winter term. A series of reports by professional examiners showed that the work of the school has been conducted in a highly successful manner. In practical electricity Mr. George A. Goodwin, president of the Society of Engineers, considered that the knowledge of the students spoke highly for the style of instruction. Mr. Binnie afterwards addressed the students on the value and importance of engineering as a profession.

An Interesting Display.—Electric-avenue, which is situated quite close to Brixton Station, is this week illuminated by 60 Fyfe-Main arc lamps of 2,000 nominal candle-power, and by 1,200 fairy lamps interspersed amongst a hundred full-sized trees, and between the columns, the entire length of the colonnade, are suspended baskets of foliage lighted by incandescent lamps. In addition to these there is arranged across the road a large number of foliated festoons brilliantly lighted with electric lamps. The illuminations surpass in brilliancy and artistic effect those of last year, and which were generally admired and visited by thousands from all parts of London. The idea of illuminating and decorating Electric-avenue emanated from and was designed by Mr. A. L. Fyfe, of the Fyfe Main Electric Lighting Company.

Electricity in Mining. — The Aberdare-Merthyr Collieries Company, in the extensive colliery under their control, have introduced electricity in place of steam power for working the pumps underground. Before the members of the North Staffordshire Institute of Mining and Mechanical Engineers on Monday, Mr. R. H. Wynne read a paper on "The Application of Mechanical Arrangements in Underground Operations." With regard to motive power he classified the subject as follows: (1) horse-power; (2) steam;

(3) compressed air; (4) electricity; (5) combustion of petroleum. Mr Wynne pointed out the advantages and disadvantages of the different systems, showing that while each was valuable under certain circumstances, electricity, when further developed, would be sure to be extensively introduced for motive power as well as for lighting.

Lighting in Brazil.—A Devonshire paper mentions that two years ago Mr James T. Cornish was selected by Mr. W. H. Preece to go to Sao Carlos do Pinhal, Brazil, to erect works and instal the electric light. After many months of vexatious delays, caused by the Brazilian Customs authorities, he at last succeeded in transporting to the distant island city of Sao Carlos a complete lighting plant, with electric motors and equipment, so that now the station is supplying 2,000 lamps of 8 c.p. for private use, as well as over 200 street lamps. So successful has been the installation, and so satisfactory has the English-made plant proved in working, that several large towns in the neighbourhood have made overtures to Mr. Cornish, notwithstanding strenuous competition by German electricians, to instal the electric light in their respective municipalities.

Defective 'Bus-Lighting.—The London General Omnibus Company were summoned on Monday, at Bow-street, for failing to light five of their omnibuses. Mr. Hicks, who appeared on behalf of the company, reminded the magistrate that some similar summonses had been heard 10 days previously, and that he had then expressed the hope that there would be no recurrence of the offence. Unfortunately, the Bristol Electric Lamp Company, to whom the contract for lighting the omnibuses had been entrusted, did not appear able to carry it out effectively, and he was so dissatisfied that, at their next meeting, he intended to advise the Board to put an end to electric lighting and go back to oil lamps. A penalty of 3s. and costs on each summons was imposed. We might suggest that the London General Omnibus Company should experiment with electric lamps of some other company.

Sludge as Fuel.—Mr. G. F. Priestley, of Halifax, has written to the papers in reference to the Leeds sewage works at Knostrop, where thousands of tons of sludge are dried in the open air. He is convinced from the experiments tried lately that these heaps could all be burnt without smell, and that sufficient power could be derived therefrom (by the generation of steam) to drive all the pumping machinery at the Knostrop works; not only this, but to supply light to Leeds. At present the sludge is given to farmers, but it has been proved over and over again that it is worth next to nothing when lime has been used as a precipitant. When burnt in the new type of steam generators at Halifax (driving an electrical plant) it is worth, he remarks, about 4s. per ton for steam raising purposes, and can be made to burn with a bright quick flame. Mr. Priestley considers that the attention of sanitarians and electricians should be drawn to these facts.

Royal Meteorological Society.—The monthly meeting of this society was held on Wednesday, Dr. C. Theodore Williams, president, in the chair. Mr. C. Harding, F.R.Met.Soc., gave an account of the "Great Storm of November 16th to 20th, 1893." He stated that this storm was the most violent of recent years, and, so far as anemometrical records are concerned, the wind attained a greater velocity than has previously been recorded in the British Islands. The velocity of the wind was 96 miles in the hour from 8.30 to 9.30 p.m., November 16th, in the Orkneys, where the hurricane burst with such suddenness that it is described as like the shot of a gun; and the wind afterwards attained the very high rate of 90 miles and upwards in the hour for *five consecutive hours*. Many of the gusts were at the rate of 115 miles an hour, and at Fleetwood a squall occurred with the wind at the rate of 120 miles in the hour. The storm was felt over the entire area of the United Kingdom. The author had tracked the storm from the neighbourhood of the Bahamas on November 7, across the Atlantic, and over the British Islands to Central Europe on November 20.

The European Sims-Edison Electric Torpedo.—Captain Grice-Hutchinson, in the House of Commons on Monday, asked the Secretary of State for War whether he was aware that the European Sims-Edison Electrical Torpedo Company, having failed to obtain any assistance or encouragement from the officer deputed by the War Office to attend the trial at Stokes Bay in February, 1892, had in consequence to transfer its operations to France; whether he was aware that two of these torpedoes had been constructed by an eminent firm in France, and favourably reported on to the French Government by a committee of naval officers; and whether, in view of the fact that France might acquire the right to these torpedoes and the secret of their construction at any moment, he would give to the company such aid as might be requisite, so as to secure to this country the possession of what was one of the most advanced system of dirigible torpedoes at present known. In reply, Mr. Campbell-Bannerman said that the trials referred to had been kept under observation, and that it was not considered that the Sims-Edison electric torpedo had the advantages possessed by the torpedo already in the service.

Electricity in Warfare.—In the course of an article in a New York paper Lieut. Zalinski deals with the subject of the pneumatic gun he has devised, and which is to be charged with dynamite. Speaking of the fleet which has left New York for the use of the Brazilian navy, he says it is much more formidable than is generally imagined. He states that the "Nictheroy" is supplied with the Fiske electric range finder. This instrument gives the range with a very great degree of accuracy, the error being less than one-half of 1 per cent., as the instruments are mounted on the "Nictheroy." She has also other engines of modern warfare, which will now receive their first practical application. Some of the most important of them are the Howell torpedo, the Sims Edison dirigible torpedo, and the Halpin dirigible torpedo. The Halpin dirigible torpedo has been recently evolved, and the experiments made with it thus far indicate effective possibilities. Its motive power is said to be obtained from a storage battery carried within it, it being steered by wires by an operator on the boat or ship. It special advantage is that it is dirigible. It may be worked from a very small rowboat, or even by an operator swimming in the water.

The Central London Railway.—Sir Horace B. T. Farquhar, who presided on Tuesday at the annual general meeting of the shareholders of the Exploration Company, mentioned that the report was late in appearing, owing to its being expected that they would be able to announce the issue of the Central London Railway. Unfortunately, however, the state of finance generally in the City was such that it would have been impossible to make such an important issue. Great delay had also been caused from their having to submit all the plans of the proposed station close to the Bank of England for the approval of the Sewers Commissioners. This approval they only received last June, and between then and the present time it would have been impossible to have made such an important issue. The chairman said it was unnecessary to take powers for the extension of the time of the Act. The railway was a most important enterprise, and when completed would meet a great want of the people of London. The directors were quite confident that there would be an enormous traffic,

which was already waiting for it, and that it would also prove a highly profitable undertaking, as electricity, which would be the motive power, was cheaper than steam.

Telephony between Dublin and Belfast.—The work of erecting the trunk telephone line between Dublin and Belfast is making rapid progress, and already the section between the Irish capital and Drogheda is complete. It is expected that early in January the line will be ready for opening, and arrangements are being made at the general post offices at either end for affording the public facilities for carrying on verbal communications. It will be remembered that Belfast is already coupled up telephonically with Glasgow, the tariff for use of the line being 1s. per minute. This line being 150 miles in length, and the new line between Dublin and Belfast being about 105 miles, it is fair to assume that the tariff between the two latter cities cannot exceed the same amount. The conductor is solid copper wire, weighing 800lb. to the mile, and in the erection the spiral system is being adopted—that is, giving the wire a spiral direction from pole to pole—the object being to neutralise the effects of induction. By this arrangement the wire completes a spiral between every four poles. By way of comparison, it may be mentioned that the London-Paris trunk line is 300 miles long, and the tariff 8s. for the use of the line for a period of three minutes.

The City Telephone Tubes.—On Tuesday the clerk to the Commissioners of Sewers read a letter from the City of London Electric Lighting Company on the subject of the telephone tubes in the electric lighting conduits, and also a letter from the Exchange Telegraph Company asking that, in the event of permission being granted for the use of the pipes laid by the City of London Electric Lighting Company, the Exchange Company might be included in the licenses, so as to use the tubes for telegraphs and telephones. The City of London Electric Lighting Company, in their letter, asked that no further delay should take place in regard to the Commissioners giving their consent to the use of the tubes. With regard to the proposed charge of £8 per annum for telephones in the City, the company thought such a charge was not compatible with the outlay of capital, and pointed out, as stated in our last issue, that the reduction of charge to 3,000 telephone subscribers would mean that the proposed cheapening of the electric light to private consumers, who now numbered 25,000, could not be carried out. Mr. Gordon, in moving that these matters should be referred to the Streets Committee, remarked that there might be some modification in the terms made by the Commissioners, and that the charge for the telephone service should not exceed £10 per annum. Mr. Stapley seconded the proposition, and said he thought the present was a good opportunity for dealing with the company.

The Government and Telephony.—"There is still no sign," remarks the *Pall Mall Gazette* in yesterday's issue, "of the appearance of the Post Office contract with the National Telephone Company, which was promised to be exhibited to members in the autumn session. It is curious to note the difference in the attitude of the past and present Postmasters-General on this question. Sir James Fergusson, speaking in March last year, stated that, supposing local authorities were willing to take telephone contracts themselves, he did not see anything contrary to Government policy in such a proposal. A Treasury minute quoted by Sir James Fergusson on that occasion declared that the Government would comply with the reasonable demand of any town or district for telephonic facilities. Notwithstanding this very definite expression of opinion from his predecessor, Mr. Arnold Morley declines to act up to it, and in the case of Glasgow, for instance, has refused the facilities which Sir James Fergusson says the townspeople are perfectly justified in asking for. Attention will be drawn to this anomalous state of things in the House of Commons early next year by several members, among them Mr. A. C. Morton, who will set down a motion declaring that the Post Office telephone contract, and all that relates thereto, shall be referred to a select committee of the House, so that the local authorities of the United Kingdom shall have an opportunity of stating their views on the question."

Magnetic Rotation.—Mr. W. H. Perkin, F.R.S., is pursuing his experiments on the magnetic rotation of hydrogen chloride in different solvents, also of sodium chloride and chlorine, and at the last meeting of the Chemical Society read a further paper on the subject, the results therein being confirmatory of those previously published. It is shown that when isoamylic oxide is nearly saturated with hydrogen chloride at temperatures between 0deg. and 25deg., no appreciable interaction takes place, the values obtained by direct weighing agreeing with those afforded by titration with alkali; action takes place only very slowly between the two substances at ordinary temperatures. Hydrogen bromide acts far more rapidly on isoamylic oxide. It is further shown that hydrogen chloride acts extremely slowly on ethylic and isoamylic alcohols at ordinary temperatures. Hydrogen chloride when dissolved in these alcohols has a higher molecular rotation than when dissolved in isoamylic oxide, the value being, however, less than that afforded by aqueous solutions, thus:

In aqueous solution	4·300
In alcoholic solution...........................	3·324
In isoamylic oxide	2·245

The molecular magnetic rotation of sodium chloride was found to be 4·080 in the solid state, and 4·068 in aqueous solution. The value obtained for chlorine, using a solution in carbon tetrachloride, was 2·188, which is considerably higher than the value calculated from compounds such as propyl chloride (1·733).

The New Pacific Cable.—In the House of Commons, on the 14th inst., Mr. Henniker Heaton asked the Under-Secretary of State for the Colonies whether he was aware that a contract was entered into last year, and now completed, between a French cable construction company and the Governments of New South Wales and Queensland for the construction of the first section, from Queensland to New Caledonia, of a proposed Pacific cable to America; whether he was aware that the French Government contributed two-thirds of the subsidy (the remaining one-third having been contributed by the British colonies aforesaid) on the binding condition that the cable material should be constructed in France, that only French officers and men should be employed to undertake the management and working of the cable during a period of 30 years; whether any remonstrance on the subject had been made to the Governments of New South Wales and Queensland by the Secretary of State for the Colonies; and whether he had any objection to state the nature of the reply from the Prime Minister of Queensland to Lord Ripon's communication? In reply, Mr. Buxton stated that the answer to the first three questions was in the affirmative. With regard to the last question, he said that a reply had been received from the Prime Minister of Queensland, in which he pointed out that the cable in question would enable the authorities to prevent much more easily the escape of French criminals from New Caledonia, this being a matter in which the Australian colonies were greatly interested.

Power Supply.—At last Tuesday's meeting of the Institution of Civil Engineers, Mr. Ellington read a paper on the "Hydraulic Power Supply of London," and the question of plant efficiency formed an important section of the paper. This is one of the ever-recurring problems in electrical engineering work, and thus comparisons were made. In the part of the paper dealing with plant efficiency the author discussed the question whether a combination of power supply during the day and the use of the energy for electric lighting during the night would improve the load factor, and arrived at the conclusion that little or no advantage in this respect was to be gained by such combination. The load factor of the hydraulic supply for the year 1887 was 0·275. For 1889, 0·338, and for 1892, 0·326. It was pointed out that the improvement of the load factors in recent years over 1887 was due to the enlarged area of supply, and not to the increased quantity of power supplied—the time of maximum demand varying in the different districts supplied. Load diagrams were given of the electric supply on December 21, 1892 (a foggy day) in Westminster, and of the hydraulic supply on the same day, and the two were combined. The load factor for the combined curve was 0·522, while the electric load factor alone was 0·533 and the hydraulic load factor 0·495. It was further pointed out that under the most favourable conditions a supply approaching the maximum would only be given on 280 days in the course of a year, and that it was impossible without storage to obtain from any combination of supplies more than 12 hours' work out of 24—a condition which would only produce a load factor of 0·380 against 0·325 actually realised. A low load factor was likely, therefore, to be a permanent cause of low efficiency in all methods of supplying energy which did not admit of extensive storage. The load factor had, however, a far greater influence upon the amount of capital outlay per unit of output than it had upon the cost of fuel and station expenses.

Self-Induction.—This title for an article appearing over the well-known initials "J. S.," in last week's *Industries*, was particularly interesting, as a long letter on the same subject was then under consideration. We only hope that "J. S." has made his text clear; we fear he has not. At any rate, "J. S." is not averse to progress, and would have consistency—but the latter he cannot have. He, although bold, cannot afford to do more than tinker. He, as are all those of the same persuasion, is compelled to take things pretty much as they are, and destroy a little here and there in order to construct a little. He would not get half-a-dozen readers or hearers were he to give full scope to reconstruction views. We trust we may be permitted to give a rather long extract from the article mentioned, which seems to embody its author's views. It says: "An electric circuit has unit self-induction when if the current increases at a rate of an ampere per second, there is a back E.M.F. of one volt. Thus if the current increases uniformly from zero to one ampere in a second, there is a back pressure of one volt, which means that if there is one turn of exciting wire, 10^8 lines of induction must have cut it in this second. If there are 100 turns of wire there must be 10^6 lines, and so on. A self induction of a henry may therefore be also defined as such, that if there is one ampere the product of the turns by the total induction enclosed by each of them is 10^8. It will thus be seen that magnetic reluctance and self induction are very closely related. Magnetic reluctance considers the magnetic circuit only, while self-induction consider the number of turns of wire in the coil, too. If the magnetic reluctance is taken as the magnetic potential divided by the total induction, it is the reciprocal of the self-induction where there is only one turn of exciting wire. The self-induction, however, varies as the square of the turns of wire in the exciting coil. For instance, if there are two turns instead of one, one ampere gives two ampere-turns, and therefore twice as much total induction, and the growing induction cuts twice as many turns. The current, increasing at a given rate, therefore generates four times the counter-pressure. There is thus a simple relation between self-induction and magnetic reluctance. The self induction is the reciprocal of the magnetic reluctance multiplied by the square of the turns in the coil."

Military Signalling.—Colonel G. E. Gouraud read a paper last Friday on the "Telephotos," a new means of electrical signalling by night and day. It is the invention of Mr. Claudius Victor Boughton, of Buffalo, N.Y. Colonel Gouraud said that signalling by flags had not made any remarkable progress since the day of the historic signal at Trafalgar. The night signals of Admiral Colomb had done and were still doing most efficient service in some ships which were not provided with electricity, and ships having command of a current and provided with mast-head electric lights effected a saving of time in displaying Admiral Colomb's time flash, with the obvious result that the increased brilliancy of the light carried with it the power of communicating to a greater distance. The theory of the telephotos was the production by electricity upon a shaft of incandescent lamps of any candle-power of the symbols of the Morse alphabet and numerals, in dashes of 5ft. length, made with 10 lighted lamps, and dots of 3in. made with one lighted lamp, and with unlighted intervals of 5ft. between each, which would bring under the eye the complete symbol at once, and was intended for use at any points within vision between which the laying of telegraph wires was impossible or impracticable. The telephotos was a combination of electrical connections contained in a case mounted on a pedestal which was fastened to the floor, having a key-board of the alphabet and numerals, like that of a typewriting machine, and the keys had raised on their underside all the Morse characters in brass, with platinum points; the crossbars, 106 in number, were flexible and embedded in hard rubber. A groove under the keys contained a number of fine steel bicycle balls, with $\frac{1}{16}$in. of lost motion, which was the thickness of a key, so that when that space was occupied by pressing one key down between the balls all other keys were locked. The key, when pressed down, came into contact with, and conveyed the current to, the crossbar by means of the raised symbol on the underside of the key, from which crossbar wires led to the lamps on the light frame, which when lighted made the Morse character corresponding to that on the key pressed down. The switchboard was 11in. by 14in., and had a capacity of controlling perfectly 106 incandescent lamps. The lamp was one of an entirely new design, representing in shape a round door-knob, with a filament of 10 coils placed crosswise in order to secure the greatest light surface for the lamp; each lamp fitted into a parabolic metal reflector, and the front of each was covered with a paralleling lens, designed at the Cornell University for this invention. Without in the least decrying the importance of either the telegraph or telephone in field service, Colonel Gouraud expressed his opinion that the telephotos would accomplish what neither of these systems could—namely, free communication along the coast between land and sea forces acting together. It could move side by side with an army in its strategic changes of position, and within vision limits by day or night be doing good work long before wires could be laid to operate either telegraph or telephone.

THOMAS PARKER.

Mr Thomas Parker, J.P., F.R.S. Edin., M.I.C.E., M.I.E.E., M.I.M.E., was born in 1843 at Lincoln Hill, near Coalbrookdale, Shropshire. The education he received when a boy was very limited, as at the age of nine years he was obliged to go to work with his father, a moulder at the Coalbrookdale Ironworks, where he continued for eight or nine years, doing the commonest and hardest work connected with the primitive method then in vogue of smelting small quantities of pig iron in little cupolas, and transferring the metal from the cupolas to the moulding shop. On leaving Coalbrookdale, Mr. Parker removed to Birmingham, thence to the Potteries, and subsequently to Manchester, where he had some means of getting the education which he failed to obtain in his earlier days. Electricity was at that time, 1863-4, beginning to be talked of as having an important future of its own, and Mr. Parker, always studious and inventive, resolved, so far as he could, to master this mysterious subject. Science, however, was only taught to those who could well afford to pay for it, and it was not likely to open its treasures to a poor youth whose only recommendation was a determination to learn, even without the very desirable preliminary of a good ordinary education. His attention was accidentally directed while at Manchester at this time to the lectures of Sir Henry (then Professor) Roscoe and others at the Hulme Town Hall, through which he soon obtained considerable proficiency. The advantage he received from Sir Henry Roscoe's lectures was supplemented on his removal to Birmingham by a course of study at the Midland Institute, which was then only recently established, but which has since been so important a factor in the educational and scientific progress of the Midlands. Mr. Parker afterwards returned to his old quarters at Coalbrookdale, where he had the offer from his former employers of a responsible position, and where he remained seven years, devising several inventions, including, amongst others, the Parker-Weston steam pump and the "Kyrle" grate, for which he received a silver medal at the Smoke Abatement Exhibition. From being himself a scientific student, Mr. Parker soon developed into a science teacher, and he gave many popular lectures in his own neighbourhood concerning the multifarious applications of the new power then claiming public attention. It was at one of these lectures that he met with his future partner, Mr. Bedford Elwell. In 1882 he founded the Elwell-Parker firm, manufacturing various electrical appliances, and at about the same time took out a patent for storage batteries or accumulators. Shortly afterwards the Elwell-Parker dynamo was invented and introduced. The first of these dynamos sold was sent to Manchester for use in depositing copper upon calico-printing rolls, and the success of this machine speedily brought orders for more. The firm at this period only employed three individuals—viz., Mr. Parker himself, a man, and a boy. Mr. Parker then became connected with the late Mr. Charles Moseley, of Manchester, Elwell Parker, Limited, being formed, with Mr. Moseley as chairman. Orders then came so quickly that the company was obliged to build new shops and greatly extend the works in Commercial-road, Wolverhampton, where special facilities had to be provided for the ever increasing demand, and this increasing business it was that finally led the firm, after it had been taken over with other concerns by the Electric Construction Corporation, to choose a large piece of land at Bushbury, a mile and a half to the north of Wolverhampton, on the Stafford road, where it is in close proximity to the London and North-Western Railway system, with which the works are connected by a special siding. The factory itself has, under the guidance of Mr. Parker, been fitted completely with the most modern tools for the production of heavy electrical plant, and lighter tools and delicate machinery for the production of other goods in connection with the trade. About 700 men are now employed at these works. Mr. Parker has taken out a great number of very valuable patents in connection with electricity, and has been engaged upon some of the greatest electrical undertakings in this country and abroad, and has been connected with more schemes for electrical traction than any man in England, the Electrical Construction Corporation under his guidance having carried out most of the tramways and railways using electricity as the motive power, including Blackpool, Birmingham Central, South Staffordshire, Madras (India), and the Liverpool Overhead Railway, this latter being the greatest engineering feat that has ever been attempted in this direction. Mr. Parker is justice of the peace for Wolverhampton, a member of the Royal Society of Edinburgh, Civil Engineers, Electrical Engineers, and Mechanical Engineers.

POLYPHASE ALTERNATE CURRENTS.

(Concluded from page 562.)

MOTOR FORMULÆ.

When an attempt is made to arrive at an exact and complete theory of these machines from which we may derive definite formulæ for constructing the various component parts, in order to yield a given result, we are met at once with several points as to which we can only make assumptions, and to get over the difficulty we must give arbitrary values to the efficiency, specific induction, etc., of any particular machine in question. The nature of the current actuating the motor must also be defined; and, finally, one particular type of machine chosen.

It seems almost impossible, therefore, to arrive at any calculation of this kind that shall be absolutely general.

This is true when we consider any electrical machine whatever, and it is only when we have to construct a motor of a type well known and constantly in use that there becomes available a large number of practical facts which may help in assigning values to the characteristics not fully determined. In such a case, when fair values are given to the efficiency and special dimensions, we may feel sure that after the machine has been built, it will work in the desired manner, under the conditions arranged for.

Owing, however, to the extremely small number of polyphase motors actually constructed and in use to-day, there is a corresponding paucity of facts and experience with regard to the values to be assigned in our equations to the indeterminates. We might, perhaps, institute comparisons with motors of a continuous-current or synchronous alternating-current type, as already in use, and with alternating-current transformers, keeping well in sight meantime the conditions that theory indicates to be the most suitable and proper. If, however, this kind of speculation—interesting as it undoubtedly is—may effect any tangible result, it can only be with the aid of a supplementary series of practical experiments undertaken as soon as possible. The following expressions, therefore, must only be regarded as indicating a direction rather than an exact path; although in themselves they may not be very far wrong, yet they have not been so far sanctioned or confirmed by practice. If A represents the total power or input, it may be expressed as being equal to $\omega_2 G \times \eta \times k$, where ω_2 = angular velocity of armature, G = total couple, η = efficiency (representing practically the electrical losses in the armature), and k = the mechanical friction losses, together with losses due to hysteresis and Foucault currents—*i.e.*, the magnetic waste. This is, or ought to be, not more than 5 per cent., so that $k = \cdot 95$.

The machine in question is considered to be of the bipolar type. In the equation $A = \omega_2 G \times \eta \times k$ the value of G, previously given, may be substituted, whence we have:

$$\frac{A}{\eta . k} = \frac{p}{2} \frac{\omega_2 N}{l} \frac{\omega^2 l^2}{\omega^2 l^2 + r^2}.$$

We can replace p, l, and N by their values in terms of the motor dimensions, and thence obtain the latter. The magnetic resistance, R, is first worked out. If y = radius of armature, z = its length parallel with the axle, x = thickness of core, and δ = width of air-space, then the magnetic resistance of the air-space is given by the expression $\frac{4\,\delta}{\pi\,y\,z}$, allowing a space equal to the air-gap width between the periphery of armature core and the holes pierced through the latter for the winding.

The total resistance of the machine may be averaged as being equal to 1·25 that of the air-space, so that

$$R = \frac{5\,\delta}{\pi\,y\,z};$$

but, as has been stated,

$$l = \frac{2\,\pi\,p}{R},$$

whence

$$\frac{2\,p}{l} = \frac{5\,\delta}{\pi^2\,y\,z} = \cdot 5066\,\frac{\delta}{y\,z}.$$

If I is the specific induction in the armature, we have

$$N = 2\,(\cdot 8\,x\,z\,I),$$

in which expression the use of the coefficient ·8 assumes that we have an armature core of laminated sheets insulated one from the other, so that an allowance has to be made for the reduction in volume of iron.

We may now rewrite our first expression thus:

$$\frac{A}{\eta\,k} = \frac{5\,\delta}{4\,\pi^2}\,m\,\omega_2\,(1\cdot 6\ I)^2\,\frac{x^2\,z}{y},\ \text{where}\ m = \frac{\omega^2}{\omega^2 + \frac{r^2}{l^2}}.$$

A very small value—say, 2mm.—may be given to δ, because the sunk winding enables the armature to run more closely to the polar faces than with exterior winding; and a value of, say, 10,000 may be given to I. From the above equation may, therefore, be deduced at once the value of $\frac{x^2\,z}{y}$, all the other components being known or obtainable from expressions previously given; and we thus have a section of the armature in a plane parallel with its axle. Its form, however, is still undetermined; and practical considerations must govern this—such as the minimum amount of cooling surface, maximum peripheral velocity for the armature, etc. In any case limits are given to the dimensions of the armature whether it be of the ring or the drum type (in which latter case, of course, $x = y$).

To determine the size of winding, we may take an armature of the type shown in the last article, where a single coil is formed of two bars of a length, z, and section, s, and two circles or rings at the ends of $2\,y$ diameter, and $\frac{s}{2}$ section, taken out of the entire mass of the copper end rings, whose total section in each case would be $\frac{p\,s}{2}$.

The resistance, r, of each coil

$$= 2\,\frac{z}{s}\,\rho + 2\left(\frac{\frac{1}{2}\,\frac{\pi\,y}{s}\,\rho}{2}\right) = \frac{2\,\rho}{s}\,(z + \pi\,y),$$

where ρ = the specific resistance of the copper employed.

It has been shown, however, that

$$\frac{r}{l} = \frac{\omega_2\,(1-\eta)}{\eta},\ \text{and}\ l = \frac{2\,\pi\,p}{R},$$

therefore

$$\frac{2\,\rho}{s}\,(z + \pi\,y) = \frac{\omega_2\,(1-\eta)}{\eta}\,\frac{2\,\pi\,p}{R};$$

whence

$$p\,s = \rho\,\frac{R}{\pi}\,(z + \pi\,y)\,\frac{\eta}{\omega_2\,(1-\eta)}.$$

We may assume a value for p contingent upon a result for s which shall agree with the armature dimensions already given.

Field Excitation.—We may assume a triphase winding with q coils upon each magnet. Then N, the total flow, may be proved equal to $\frac{\pi^2\,y\,z}{5\,\delta}\,q\,C$, where δ = width of air-gap, and C = strength of current in one of the windings. But N has been shown equal to $1\cdot 6\,x\,z\,I$, and I is given. Hence we have—

$$1\cdot 6\,x\,z\,I = \frac{\pi^2\,y\,z}{5\,\delta}\,q\,C,$$

and

$$q\,C = \cdot 8105\,I\,\delta\,\frac{x}{y}.$$

This result, however, gives no more than the number of ampere-turns required for the proper excitation. C and q must be individully assumed and trials made until values are obtained consonant with the other results and the general conditions of working.

Coefficient of Self-Induction in the Field Circuit.—This may be obtained from the expression,

$$q\,\frac{12\,q}{R}\,\sin\frac{\pi}{3},$$

and since R may be shown equal to $\frac{30\,\delta}{\pi\,y\,z}$, we have

λ (or coefficient of self-induction)

$$= \frac{\sqrt{3}}{5}\,q^2\,\frac{\pi\,y\,z}{\delta} = 1\cdot 089\ q^2\,\frac{y\,z}{\delta}.$$

TRANSFORMING POLYPHASE ALTERNATE CURRENTS INTO CONTINUOUS CURRENTS.

If we send through the armature of a continuous-current machine, alternating currents differing in phase (if, for example, triphase currents are thus employed, entering at points in the winding placed at 120deg. from each other), there results, as we have already seen, a rotary magnetic field. If, therefore, this armature is placed in a magnetic field, N S (see Fig. 23), of constant strength produced by any suitable means whatever, it will rotate in the ratio of one turn per period.

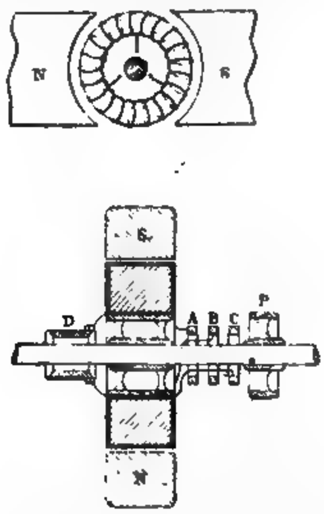


FIG. 23.

Suppose, now, that on the same spindle and in the same field, N S, is mounted the armature of a continuous-current machine, evidently at the brushes of the second armature we may derive a continuous current. The two windings may be placed on the same armature, or, further, there may only be a single winding, arranged as shown in the illustration (Dobrowolski).

The armature is mounted between the two pole-pieces, N S. It is wound in the usual fashion for continuous-current working, the coils being connected to the commutator, D. At three points in the winding—120deg. apart—a connection is also made with each of the three collecting rings, A, B, C. P is the driving pulley.

An appliance of this kind may be operated in any of at least six different methods:

1. Continuous current motor.
2. Synchronous triphase alternating-current motor.
3. Continuous-current generator.
4. Triphase alternating-current generator.
5. Transformer of continuous into triphase alternating currents.
6. Transformer of triphase alternating into continuous currents.

The last development alone need here be touched upon.

It is plain that by the use of a single winding, or of two windings upon the same armature, the efficiency of the machine is much greater than when we have two armatures upon the same spindle. In the former case, the mutual induction of the two circuits puts self induction to a profitable use. To employ two windings, moreover, allows the E.M.F.'s to be varied in any desired ratio, whilst with a single winding the ratio is constant.

In the annexed illustration, Fig. 24, is shown the scheme of a ring armature winding divided into three sections of 120deg., through which triphase currents are passed; but, of course, similar methods of working out the details would apply in the case of a rotary field produced by any number of displaced currents, or by the use of any arrangements such as those already described.

Fig. 24.

In a transformation of this kind the triphase rotary field, placed in a constant magnetic field, N S, is in reality fixed in space, and it is the armature which rotates synchronously with the period of the alternating currents employed,

$$\omega_1 = \frac{2\pi}{T}.$$

In this case the brushes through which passes the continuous current are fixed.

It may be shown that if k is the efficiency of the ring, the continuous current will have a strength

$$\gamma = k c = k \frac{3}{2} \sqrt{3} \frac{P}{Q} C,$$

where P = total number of wire turns, Q = number of wire turns through which the continuous current passes, and C = maximum strength of current in any section. The corresponding E.M.F. will be given by the relation $E = n_1 Q N$, where N = total flow from one pole to the other, n_1 = number of revolutions per second (if the rotary field is bipolar as we have so far assumed, then $\omega_1 = 2 \pi n_1$).

The power developed is $E \gamma = k n_1 N \frac{3}{2} \sqrt{3} P C$.

It may be noted that N depends both on the strength of the field, N S, and that of the field due to the triphase currents. Evidently we may suppress the exterior field, N S, and only present at each instant to the flow of the rotary field a magnetic circuit through which it can be closed on itself.

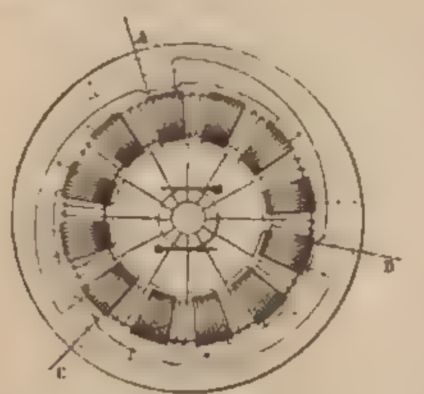


Fig. 25.

In the arrangement shown in Fig. 25, the magnetic circuit is closed by a ring exterior to the armature. The consequence is, that at each instant the flow has a path along which to close itself. The whole appliance is fixed, and the brushes alone turn round with a speed synchronous to that of the rotary field. This action is easily obtained by means of a small synchronous alternating-current motor.

All the windings already described—which allow of obtaining a rotary field (bipolar)—can be thus employed. In the illustration, a 12-coil winding is supposed to be used.

ON INSULATION AND FAULT DETECTION IN THREE-WIRE SYSTEMS *

BY WM. ROWAN WILSON, B.SC.

This paper is an attempt to show how the tests and processes which apply to other simpler systems work out when applied to the three-wire system, and to describe shortly the practice at the Glasgow Corporation electric lighting station, some of the processes being, I believe, novel. A good number of preliminary trials have been made in various directions, both in the laboratory at Waterloo street and also outside, in the streets, under the supervision of Mr. Arnot, the chief engineer. But passing over these, without touching on past successes or failures, we are led to consider first the apparatus used for giving at a glance the state of the insulation of the mains, etc., at any moment. This consists of two of Lord Kelvin's vertical multicellular voltmeters, one of which is joined from the positive of the street conductors to earth, and the other from the negative to earth. There are thus two electrostatic voltmeters in series across the 200 volts, and their "common point," so to speak, is joined to earth. The middle, or neutral, wire does not directly come into the apparatus at all. Suppose the system to be clear of faults, the voltmeters will be found to read nearly 100 each, but not usually exactly 100—*e.g.*, one might be 80 and the other 120. If now the positive becomes earthed, the positive voltmeter will fall to nearly nothing, and the negative one rises to nearly 200 (of course the sum of the readings must be 200). Or, suppose an earth on the middle wire, the voltmeters will both come to 100 exactly. We thus know at once when and on what main a fault arises; and although the apparatus is, as will be seen later, solely a recorder of the ratios of the insulations to each other, it is quite sufficient for the purpose for which it is designed. To calculate the absolute insulation of each main the voltmeter readings are taken as above, and also the current leakage from each two wires, by connecting the other through a very low-resistance ammeter to earth. There are thus obtained three current readings on the ammeter, as follows:

C = current through ammeter joined from positive to earth.
D = " " " " middle "
E = " " " " negative "

Call for the sake of calculation—

x insulation of positive main from earth.
y " middle " "
z " negative " "

And—

P difference of potential between positive and earth.
Q " " " middle "
S " " " negative "

By Ohm's law—

$$C = \frac{200}{z} + \frac{100}{y}$$

$$E = \frac{200}{x} + \frac{100}{y}$$

$$\therefore C \sim E = \frac{200}{x} \sim \frac{200}{z}$$

As we do not know which of the two, C or E, is greater, put symbol $\sim$

$$\therefore \frac{C \sim E}{2} = \frac{100}{x} \sim \frac{100}{z}.$$

$$\text{Also} \quad D = \frac{100}{x} \sim \frac{100}{z}.$$

$$\therefore \quad D = \frac{C \sim E}{2}.$$

Suppose a resistance put in parallel with the greater of the two insulations, x and z—*i.e.*, let a resistance be joined from the positive or negative to earth and varied till D = 0.

This resistance evidently would be $\frac{100}{D} = \frac{200}{C \sim E}$; but the experiment can be tried.

Then, it is evident that when this is done we make

* Paper read before the Physical Society of Glasgow University

positive insulation (for the time) equal to negative insulation (for the time being); see equation for D when D = 0.

Suppose for clearness $x > z$. Then

$$z = \frac{\frac{100}{D} x}{\frac{100}{D} + x}, \text{ i.e. } (z = x \text{ and } \tfrac{100}{D} \text{ in parallel}).$$

This gives a relation between z and x.

Now consider the voltmeter readings, P, Q, and S, and suppose for the moment the insulation of the neutral wire pretty good (this would at once appear from the ammeter tests, and if it were not good, the calculation is quite superfluous). We have a leakage current running from positive main to negative *viâ* earth equal to $\frac{200}{x + z}$, and if $x > z$ we have a leakage from the neutral to the negative *viâ* earth equal to $\frac{100}{y + z}$.

Of these two leakage currents the former is greater than the latter, and the method, for rough calculations, is to neglect the latter, and in the result make a percentage correction to allow for the error so introduced. However, the correction is unnecessary, because as the insulation varies so much the results are only within 10 per cent. no matter how much care is taken, and the correction would not exceed this unless there were a fault on the neutral wire.

The reading P on the voltmeter is the fall of potential due to current $\left(\frac{200}{x+z}\right)$ above, in the resistance x; and the reading S is the fall due to both leakage currents $\frac{200}{x+z}$ and $\frac{100}{y+z}$, which go in the same direction through z. If, as above stated, the smaller be neglected,

$$S = \frac{200}{x+z} \cdot z;$$

also

$$P = \frac{200}{x+z} x;$$

$$\therefore \frac{S}{P} = \frac{z}{x}.$$

But as above

$$z = \frac{\frac{100}{D} x}{\frac{100 + Dx}{D}},$$

$$\therefore \frac{Sx}{P} = \frac{100x}{100 + Dx};$$

$$\therefore DSx^2 + 100Sx = 100Px;$$

$$\therefore DSx + 100S = 100P;$$

$$\therefore \quad x = \frac{100P - 100S}{DS}.$$

This deals only with constants which have been obtained, and ∴ gives x. y and z are obtained from the former equations.

For instance, take the following case:

P = 120	C = 3·5
Q = 20	D = 0·5
S = 80	E = 2·5

$$\therefore x = \frac{100(120 - 80)}{\frac{1}{2} \cdot 80}$$

$$= 100.$$

also

$$\frac{x}{z} = \frac{120}{80} \quad \therefore z = 67,$$

and putting in

$$2{\cdot}5 = \frac{200}{100} + \frac{100}{y}.$$

$$\therefore y = 200.$$

These results show the tendency noted by Prof Kennedy of the negative main to go towards earth (so to speak). This method is simple and quite accurate enough for the purpose. The insulation is roughly calculated in this way each morning at Waterloo-street station, and the results are noted. Of course, the symbols take away from the apparent simplicity and make the process longer. The whole experiment really takes about three minutes in practice. Also, approximate results only are tried for, as the insulation varies so much each instant that, in spite of the utmost speed being used, the values may change 10 per cent. before the end of the experiment, and, therefore, as pointed out above, an approximate method of calculation is quite good enough.

All the constants have been, at times of comparative rest, obtained by Lord Kelvin's balances and voltmeters, but, for the above reason, this is scarcely worth the trouble.

With regard to insulation, the Corporation of Glasgow insists on 60 megohms per lamp from its customers, and the mains are fully up to this standard, the state of the weather seeming to make absolutely no difference in the insulation so far as can be judged.

With regard to the instruments used, the voltmeter must be electrostatic, as if current-using instruments be used we have really only a modification of the celebrated "lamp test," which, although everyone does not know it, for a large network of mains is of no real value except to mislead the public, for which purpose I have heard that it is frequently used both in London and elsewhere; for instance, if the insulation be very low, all round, in comparison with the resistance of a lamp, the lamp will not glow unless there be one or more heavy faults on the mains, although the current leakage would in this case be somewhat large.

In finding out faults, the method at first used was to divide the city network into five districts, and feed each from a feeder. This was done at a time of light load. The ammeter is joined from the good main to earth, and gives a fairly large reading (if too large half an ohm or so of resistance is put in), and the feeders are separately drawn for a moment. On drawing a certain one, the pointer of the ammeter falls to near zero, and the fault must be in the district from which the current was cut off. This narrows the search to a feeder and a mile or so of network, and this had to be gone over with an ordinary detector after cutting the current off from the district.

In practice, however, a method is required which renders the disconnections of sections of network, always a troublesome task, unnecessary. This is achieved in the following manner. A pocket compass is taken to the manhole where the feeders leave the station, and laid on one of the feeders on the side of the system on which the fault lies. The needle is then brought parallel to the conductor on which it lies by means of a strong bar magnet, which serves also to render less important any changes in the magnetic field around due to varying currents in the other feeders.

The needle having come to rest, the other side of the system is momentarily earthed; this causes current to flow through the feeder to the fault, and by earth to the other main. The direction and, roughly, the magnitude of the current flowing are known by the throw of the compass needle.

There are now two possible considerations: (1) should the current-flow point to a fault inside the station, and (2) should the flow point to a fault outside. The first case is obviously easily dealt with, as it is really only a simple form of the second case, and, in case of any difficulty, can be followed out in the same manner. In the second case the compass is applied to each feeder separately, and that on which the largest current goes to the fault, noted. The compass is then taken to the feeding point of that feeder and applied in a manhole. There are, as a rule, three or four lines of network leaving each feeding point, and the line which carries the heaviest current to the fault is easily found; this is then followed, tests being made at each manhole with the compass, and the heaviest earth-seeking current always followed till a point is reached where the direction of the earth-seeking current is seen to be reversed. The fault must lie between this and the last manhole at which the test was made, and this at once narrows down the field to be searched to a single line, at most, 100 yards long. The second instrument is now brought into use, but before describing this it should be noticed that there is a possibility of the fault being upon the feeder in question,

in which case the earth-seeking current will be found to come back from the network along the feeder, and we have the same case as above—a line of a certain length with a fault in it.

The appliance referred to which is now to be used consists of a straight length of 20ft. of insulated wire having, from its ends, leads brought out at nearly right angles and joined to a telephone receiver. Thus there is a triangular circuit whose longest side is 20ft. and which contains a telephone. On laying the straight length parallel to a conductor and making a momentary current in that conductor, the telephone is heard to buzz. This being so, the method of finding faults by the apparatus is to join the faulty length of cable to the mains at one end only, and to periodically connect the good main to earth, say, each half-minute. A current now flows from the network, along the faulty cable to the fault, and back by earth on each momentary earthing of the good main. The straight length of inductor wire is laid parallel to the faulty cable at the end where the latter is connected to the mains. On each momentary earthing, the earth-seeking current causes a rustle in the telephone, and if the 20ft. inducing length be carried along, it is obvious that when the fault is passed, the noise ceases. By practice, the fault can be located to about a yard with this apparatus, and the only thing left to do is to dig up the ground and repair the faulty conductor. Of course, this use of the telephone also applies to the case of a fault in a feeder composed of a mile of armoured cable with no joints, and this method of working would, in such a case, save great expense. Also in a concentric system the compass would find a fault (or short-circuit) with ease, where every other method involves great trouble and cost. The current in such a case would affect the needle, because the outer conductor being earthed (or easily made so), the current in the inner conductor will be much the stronger, as it has only one path open to it, while that in the outer has several equally good. The telephone would also be applicable to this case, and the advantage claimed for the telephone is, of course, the method of using it with direct current, and avoiding all trouble with motor-generators, etc., on the streets, as when the alternate current is applied for the same end.

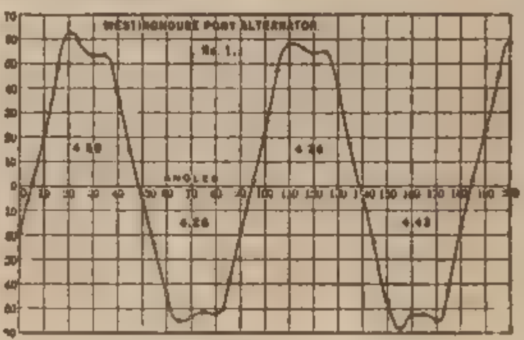
The appliances used for fault detection are, as appears, neither complicated nor expensive. The compass shows direction and, roughly, strength of current, but must be applied very close to the conductor. The telephone shows existence of current, but not direction, and may be 5ft. away from the conductor. The sensitiveness of these is such that faults under 10 ohms resistance can be found; this sensitiveness could be increased, but probably increased disturbance from the other mains would cause confusion, and a fault of greater insulation than 10 ohms can safely be left alone, as it will very soon get either worse or better.

Using these methods and apparatus, no difficulty has been experienced in keeping the mains at Glasgow free of permanent earths, and we consider that these embody all that is necessary for the keeping of a three-wire system of mains clear of leakage and its attendant evils.

IRREGULARITIES IN ALTERNATE - CURRENT CURVES.*

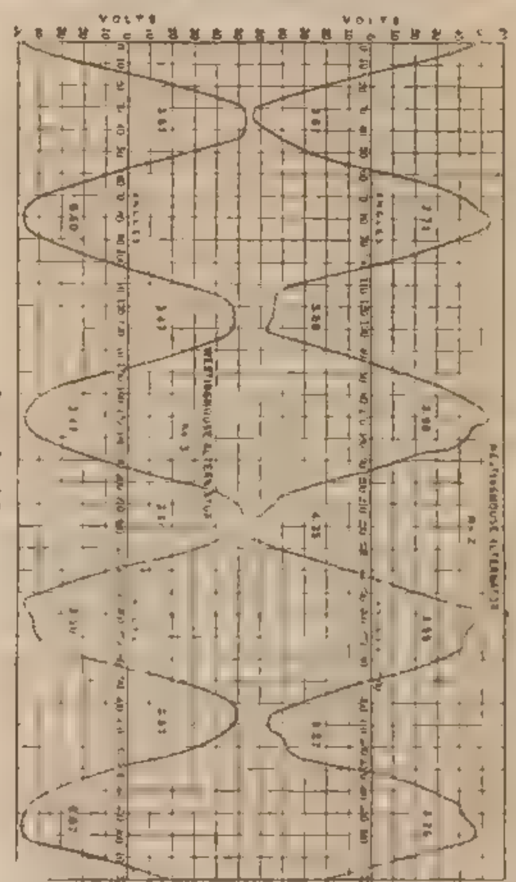
BY FREDERICK BEDELL, K. B. MILLER, AND G. F. WAGNER.

Curves of a more or less sinusoidal nature are commonly plotted to represent the instantaneous values of an alternating current, and various conclusions are drawn from their forms and relative positions. For any perfectly symmetrical generator the curves for successive periods are the same, both in shape and size, but decided differences may exist between the successive portions of the curves for machines which are not symmetrical. In the larger machines this difference is not likely to exceed 1 or 2 per cent., not introducing serious error into the mean results, although occasionally a greater difference may be found. In the smaller machines, however, the instantaneous curves show marked irregularities, so that to take one period as typical is not always justifiable.



Curve 1.

To investigate this point experimentally, Curves 1, 2, and 3 were taken from three small eight-pole Westinghouse alternators, showing the instantaneous values of the E.M.F. The E.M.F. was measured by means of a Thomson multicellular voltmeter connected around one of two incandescent lamps connected in series across the terminals of the machine, the whole E.M.F. being readily found by a proper calibration. The instantaneous reading was obtained by means of a revolving contact-maker on the shaft which made the contact at a definite point in the revolution of the armature, as indicated by a graduated disc. The three machines from which Curves 1, 2, and 3 were taken were



Curves 2 and 3

apparently alike in all respects. An inspection of the accompanying figures shows a decided difference in the curves from different machines, and also differences between successive periods of the same machine. This is further seen by comparing the areas of consecutive loops of the curves, as marked upon them. The resistance used was non-inductive, and whether the curves represent current or E.M.F. is merely a question of scale. In any case, the ordinates of the present curve represent the instantaneous values of the current, $i = \frac{dQ}{dt}$; and the area enclosed by the curve is $\int i\, dt = Q$—that is, the area enclosed by the current curve is proportioned to the quantity of electricity which flows, and for a complete cycle or revolution of the armature must be zero, inasmuch as there is no continual

* A paper read before the Madison meeting of the American Association for the Advancement of Science, August, 1893.

flow one way or the other. Likewise, the ordinates of the E.M.F. curve represent the instantaneous values of the E.M.F., $e = \frac{dN}{dt}$, and the area enclosed is proportional to the change in the number of lines of magnetisation through the armature. Evidently the algebraic sum of these areas must be zero for a complete cycle, since the magnetisation is the same at the beginning and end of a complete revolution of the armature. To establish this point experimentally, Curves 2 and 3 were taken, each for a complete revolution of the armature. In these curves, ordinates represent E.M.F., and abscissæ the portion of the cycle, with reference to the position of the armature at which readings were taken. The areas of these curves were obtained by a planimeter, and in arbitrary units are:

Areas, Curve No. 2 — Positive.	Negative.	Areas, Curve No. 3 — Positive.	Negative.
3·71	3·61	3·51	3·50
3·98	3·59	3·47	3·47
3·58	4·35	3·68	3·60
3·25	3·27	3·57	3·67
14·52	14·82	14·23	14·24
Total – ·30		Total – ·01	

Although, separately, the positive and negative areas widely differ, the sum of the positive and negative areas are very nearly equal, thus experimentally establishing the conclusion reached above.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE INSTITUTION COUNCIL.

The following letter was issued from the offices of the National Telephone Company, Limited, to the company's employés and others happening to be members and associates of the Institution of Electrical Engineers. The suggestion did not apparently meet with acceptance, since the nominee was not elected—a result not to be regretted, for the proceeding was in unquestionable bad taste, and the interference of a commercial company in the affairs of a technical institution is scarcely to be encouraged. The letter is as follows:

"National Telephone Company, Limited,
"London, E.C., December 8, 1893.

"Dear Sir,—You will probably have noticed that telegraph and telephone interests appear to have been over looked in the preparation of the Council list for next year. There is a strong feeling among telegraph and telephone men that they should be represented in the Council of the Institution. May I therefore suggest that the name of Mr. Dane Sinclair might very properly and usefully be substituted for one of the four names suggested by the Council, as Mr. Sinclair is an old telegraph man, and now engineer-in-chief to the National Telephone Company, Limited. Should this meet with your approval, perhaps you will kindly use your influence in this direction amongst your friends.

"Trusting you will pardon the suggestion, I am, yours faithfully, "THOMAS FLETCHER."

SHUNTS.

SIR,—The plaint of "H. L." has aroused my sympathy. His case is undoubtedly a sad one, but the confusion, or, to quote his own words, the "fool's paradise," in which he finds himself is possibly due to two causes—*i.e.*:

(1) The rule of thumb methods of old electricians; and
(2) Rule of thumb methods of modern engineers.

The word "shunt" had, of course, its origin in railway work, and 30 or 40 years ago sufficiently expressed the effect of introducing into an electrical circuit another circuit of lesser resistance. The phrase was familiar to all, and while there was and is a difference between a railway shunt (or, more properly, branch line) and a shunt electrical, the effect of both was apparently the same, and the comparison sufficed at that time for all practical purposes. Culley and the majority of his contemporaries taught that a shunt *diverted* current, as a rough rule to go by, but they must have known better, and I should be greatly surprised to hear that any practical electrician ever really credited so obvious an absurdity.

The question seems to me to be whether E is or is not constant. $C = \frac{E}{R}$, so that whatever changes are made in R no difference should be made in E, which is by implication unalterable. Let us see what Kempe says: "If we call C the current passing through the galvanometer without a shunt, then, on introducing the shunt, C will divide between the two resistances, the greater portion of the current going through the smaller resistance, and the smaller portion through the greater." This clearly points to *diverting* or *shunting* C, but not to altering E. But he also says: "the current which would flow through the galvanometer when the shunt was removed would be $\frac{\text{galvanometer} + \text{shunt}}{\text{shunt}}$ times the strength of the current which flows when the shunt is inserted. If *strength* in this case means intensity, it follows that E is alterable; if it does not mean intensity, it must at all events be due to alteration of pressure. Again, he says that the action of a shunt is to *reduce* the total resistance in the battery circuit, and so *increase* the strength of the current passing out of the battery. He says, in fact, that if we reduce R we increase the strength of C.

"If we employ very high resistances," says Kempe, "to measure a low resistance, a considerable alteration in the former would produce very little alteration in the current flowing through the galvanometer, *for the E.M.F. being constant*," etc. The italics are my own. Here we have a direct statement—and it has also been made by other writers—to the effect that E is unalterable, or, at all events, is unaltered, whereas we know that it must be alterable, and *is* altered. Ohm's law is inflexible. If it can be applied to one circuit, it can be applied to a thousand circuits. It is either correct or incorrect: and if we are to believe that E is constant, why the formula $E = CR$?

By $C = \frac{E}{R}$ we see that C is variable; by $E = CR$ we see that the resultant E is variable; and by $R = \frac{E}{C}$ we see that R is variable, but C would not be variable in a branch if E were constant. Let us, however, suppose, for the sake of argument, that E *is constant*, but let us call it *pressure*. If the pressure in a circuit were constant, a thousand shunts might be introduced without the slightest effect; the pressure would be as great on the galvanometer coils with as without the shunts. It is absurd to say that if the head of water in a vessel remained absolutely constant, the pressure exerted by it could be affected by a multiplication of channels, and it is equally absurd to propound the theory that electrical pressure being constant the multiplication of circuits can have any effect upon the current flowing in the original circuit. It is very convenient to consider E as a fixed quantity, but it does not follow that because it is convenient it is correct. It would be equally simple to consider C as a fixed quantity and deal only with the changes produced in E, but, as a matter of fact, R must vary both of them, and any alteration in the conductivity or resistance of a simple or compound circuit must produce a difference in pressure, and a consequent difference in the current flowing. Shunts, derived circuits, and parallel circuits, are all methods of relieving pressure. In other words, reducing R increases C, but increases it by opening the floodgates, and at the same time decreasing the head of pressure which had been acting upon them. The word "shunt" is in itself a misnomer. It should be called a "relief," or "sluice," or some other word which would more accurately express the theoretical effect of its action.

I will conclude with another example from Kempe. Speaking of the joint resistance of two or more parallel circuits, he says: "Two wires of equal conductivities, when joined parallel to one another, will evidently conduct twice as well as one of them; and in a like manner, *three* wires will conduct *three* times as well as one. Similarly, two wires, one of which has a conductivity of 2, will, when combined with one which has a conductivity of 1, produce a conductivity of 2 + 1 or

3. . . . Applying the foregoing law, the resistance between the terminals of the galvanometer before the introduction of the shunt being G, that on the introduction of the shunt will be $\frac{G\,S}{G+S}$." Where, Mr. Editor, does the *splitting* come in here? There is simply a large increase of area and conductivity due to the introduction of the shunt. No splitting can take place, and no change can be produced in the current flowing through the galvanometer, unless the pressure is relieved.—Yours, etc.,

SIDELIGHT.

SIR,—Perhaps I can assist your correspondent "H. L." The point that is omitted in the explanation of the action of shunts applied to galvanometers is that the E.M.F. at the terminals of the galvanometer is lowered by the passage of current which passes through the shunt, by reason of the charge made upon the initial E.M.F. for the passage of the current through the generator, whatever it may be, and the wires and other apparatus through which the current may pass on its way to the generator. If, to take a simple case, a cell or a number of cells of a given battery are connected directly to the terminals of a high-resistance galvanometer, the E.M.F. present at the terminals of the galvanometer is very nearly the full E.M.F. of the battery at the moment, because the current passing in the circuit and through the battery itself is very small, and therefore the charge for its passage, calculated from the formula $E = C\,R$, is also very small; E, in this case, being the fall of E.M.F. from the total E.M.F. generated in the battery; C, the current passing in the circuit; and R, the resistance of the battery and connecting wires. When a shunt is added, the factor C immediately increases, because the total resistance of the circuit has decreased in proportion to the well known law of derived circuits. C being increased, E, the charge for the passage of C through the resistance offered by the battery and connections, is also increased, and so the E.M.F. at the terminals of the galvanometer is decreased, and, of course, with it the current passing through the galvanometer coils.

When a shunt of very low resistance is applied to the galvanometer, practically no current passes through its coils, because the E.M.F. at its terminals is reduced to nil. Wherever this reasoning does not hold good, no shunting, in the sense that is usually understood, takes place. Thus, with a shunt-wound dynamo, the current passing in the shunt coils decreases as more current passes into the external circuit, not because of the lower resistance of this outer circuit, but because the E.M.F. at the terminals of the shunt coils is lowered, owing to the charge on the initial E.M.F. for the passage of the increased current through the armature coils.

Where the E.M.F. is maintained constant at the terminals of the dynamo as by the addition of the main coils, the current in the shunt actually increases as the current passing in the outer circuit increases, where the shunt coils are connected to the brushes.—Yours, etc.,

Cardiff Electrical Works. SYDNEY F. WALKER.

[We do not think our correspondent "H. L." is quite so puzzled as he makes out to be, but is rather on the growl at the time wasted in reading and hearing explanations that are false, and desirous of knowing what text-book will give him correct information. Of course, Mr. Walker fully understands that not one per thousand of students realises that his shunt to his galvanometer is not merely a by-path—or a diversion. Unfortunately, the books tell him it is when it is not. Mr. Walker sees "H. L.'s" point, while a contemporary, setting itself up as a caustic, really a flippant, critic, does not. This contemporary always reminds us of a certain squire whose mental imbecility was only equalled by his unparalleled conceit, to whom a critic suggested a subcutaneous injection of a concentrated essence of brains as a medicine much to be desired.—ED. *E. E.*]

NOZZLES USED IN FORCED DRAUGHT.

SIR,—A month or two since many of the technical journals, under the heading of "Duplex Nozzles," published certain disparaging statements as to the status of an old and tried friend—viz., the solid, simple, or central steam-jet as applied to blowing purposes. As strong conservatives in this matter, we ask you to allow us to reply on the other side.

Sir Wm. Siemens was, we believe, one of the first to claim higher efficiency for the annular over the central or solid steam-jet for blowing purposes. We had, however, supposed that no one in these days who had given the subject any practical consideration would now support the proposition. It should, however, be noticed in the first place that a nominally annular jet is not really so unless the air, or whatever other fluid is to be propelled, is admitted into the annulus through the centre, as in the blowers designed by Sir Wm. Siemens. In the duplex nozzle referred to above not only is no provision made for admitting air inside the annulus, but the annular jet itself acts as a shield to prevent access of air to the central or solid jet. This explains the advantage of the interrupted annulus of the duplex nozzle, the three or four jets in the ring allowing access of air to the central jet as well as all round themselves. We have made the subject of jet blowers a special study for the last 10 years, and with respect to the form of nozzle have come to the definite conclusion that the central or solid jet is the most efficient for all ordinary purposes, and that any departure from this not only increases the first cost and adds useless complications, but actually detracts from the efficiency.

Having these very decided opinions, we were rather surprised at the prominent position given in the technical Press to the alleged advantages claimed for the duplex nozzle. To leave no room for doubt, we obtained one of the duplex nozzles (as well as the combining tube supplied with it) and conducted a series of tests with it, the results of which we give below. The nozzle has a central jet $\frac{3}{32}$in. diameter, and three jets in a ring surrounding the central jet and having a variable opening, the full maximum area being equal to that of a solid jet of upwards of 7mm. diameter. The duplex nozzle was regulated so as to give the same effect as a solid central jet of 4mm. diameter, which is considerably larger than our average size. The size of nozzle—viz., 4mm.—was taken as a standard for comparison as being the size of nozzle in the third type of blower referred to later on. The position of the regulating screw in the duplex nozzle was found after making several tests with various forms and sizes of combining tubes giving equal volumes of outlet air at equal pressures. The air pressures tested were $\frac{3}{8}$in. water column, which may be taken as a normal ashpit pressure, 1in. water, and 2in. water. To arrive at the proportional efficiency of the nozzles, an air-receiver of a certain capacity was filled with cold dry air at 20lb. pressure above the atmosphere, and emptied first through the duplex nozzle, with the regulator in the proper position, and then through the simple nozzle. This was repeated several times, and it was found that the duplex nozzle reduced the pressure from 20lb. to 5lb. in 25 seconds, whereas the simple nozzle, giving the same effect, required 45 seconds. In other words, the duplex nozzle to give equal effect, required 80 per cent. more steam than the simple central nozzle.

We presume, however, that the efficiency of the nozzle as such is of secondary consideration, and that the really interesting question is as to the relative efficiency of the complete blowers. To ascertain this a series of experiments were made with the duplex nozzle and the combining tube supplied with it, with our own blowers of various sizes, and with a third form of blower which has recently been *en evidence*. The air pressures tested with were as mentioned above, $\frac{3}{8}$in., 1in., and 2in. water column, the corresponding steam pressures being 16lb., 42lb., and 70lb. above the atmosphere.

The net result of the series of experiments is to show that to do a given quantity of work, where our blower required a unit weight of steam, say 1lb., the duplex arrangement used between $2\frac{1}{4}$lb. and $3\frac{3}{4}$lb., and the third form of blower from 2lb. to $4\frac{3}{4}$lb.

As the question of forced or assisted draught is continuously coming more to the front, and as the steam-jet offers the simplest and, for the most purposes, the best form of blower, we think the figures given above should be of interest to many of your readers.—Yours, etc.,

MELDRUM BROS.

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CONTENTS.

THE INSTITUTION.

The annual meeting of the Institution last week brought out two questions which seem to be agitating the minds of some of the members. One of these relates to the constitution of the Council, the other to the work of the Institution. The latter is the easier to deal with. When the President stated that the report was open to discussion, and invited the members to criticise, one member rose up to complain that the Institution ought to, but did not, interfere in the purely commercial question of competitive prices in wiring. We cannot say we were surprised at the member's complaint, because some undoubtedly hold that the Institution should not only regulate prices, but find work for particular firms on their own terms. Perhaps the grumblers would like a little financial assistance as well, and for that purpose desire the run of the Institution's bank-book. How any reasonable man can expect an institution of the position of the Electrical Engineers to interfere in purely trade matters is beyond comprehension. Was not a special branch of the London Chamber of Commerce founded in order to discuss these trade difficulties, and if so, why has not the member desirous of mooting the subject brought it before the tribunal formed for the very purpose of considering, among other things, the amenities of competition? If the various firms will cut each other's throats, that fact calls for no interference from the Institution, but should be rather a matter for congratulation, in that, having got rid of a number of unbusinesslike men, the probability would be to create a better race of business men. The simple remedy for cutting prices is to leave such jobs severely alone. If the prices are really too low, the firms engaged in the practice must come to an end, and will come the sooner if their prices and bad workmanship are allowed full effect. However great our sympathy for those who would do good work at a proper cost, we cannot see how any institution or chamber of commerce can really prevent "cutting prices." The olden days of guilds are abolished, and now there exists nothing but a desire of keeping out of the bankruptcy court to keep up proper prices. At any rate, the Institution has nothing to do in the matter, and the question was hardly one that the Institution could notice. It seems very hard for firms who want to do good work that they are kept out because of firms who must intentionally tender at prices that prevent good materials or workmanship being used.

The composition of the Council is another matter, and legitimately brought forward. No doubt it is an honour to be proposed on that body, and as far as possible each branch of the profession should be represented thereon, and for our part we think most branches are so represented. It is not so many years ago that we had to urge the claims of others than telegraphists, and according to the critics the pendulum has swung too far, leaving "old-timers" and telephonists out in the cold. As for the latter, they scarcely deserve representation. They have added little or nothing to scientific or practical literature through the pages of the *Proceedings*—

and dumb animals are not wanted in the Institution. We have enough drones as it is; so that the outgoing Council is amply justified in not placing a representative drone upon its house list. The President, in answer to a question, referred to the difficulty of getting papers, and no doubt the Council does and must lean upon those sections of the members which provide papers, and these sections thus obtain larger representation than other sections like. Why not suggest an intellectual uprising amongst the telephonists and telegraphists? Send in a few good papers, show you do belong to the profession, and because of such activity demand representation. You will surely get it; but to ask proportional representation, and not to give assistance in carrying on the work of the Institution, is a little too much.

OBITUARY.

THE LATE WILLIAM HUBERT PARKER.

It is with great regret we have to record the death of William Hubert Parker, who was for many years our esteemed colleague. Mr. W. H. Parker was the son of the Rev. J. Parker, and belonged to one of the best-known Worcestershire families. He was educated at Bradfield College, afterwards at the School of Telegraphy, and entering the Eastern Telegraph Company's service he spent a probationary period at Porthcurnow. Subsequently coming to London he became assistant editor of the *Contract Journal*, and also assisted in the production of this paper. A large number of friends have met him in one or other of these capacities, and those who were intimately acquainted with him knew him to be one of the most able, painstaking, and conscientious of literary men. He endeared himself to those he met, and his loss will long be felt, not only by his own family, but by a wide circle of sorrowing friends. Mr. Parker has had a lengthy illness, and earlier in the year took a voyage to Tasmania, but with little benefit. On returning, he gradually became weaker, and died on Monday last.

WOODHOUSE AND RAWSON.

The summary of the statement of affairs on May 17, 1893, the date of the winding-up order, and the official observations thereon are now in the hands of creditors. This summary reaches to nearly 24 pages of closely printed matter, with tabular statements throughout, and is a statement which fully bears out all our criticisms about this Company's affairs. A close attention to this summary will show that the Company never had a chance of success, and was carried on in a most irregular manner. It would be a disgrace to commercial enterprise if the men who had the control of this business were ever permitted to run another commercial concern. Five companies were originally amalgamated. Into the history of these we need not enter. We would like, however, to point out that in the course of time no less than 11 people were connected with the directorate, of which number, from the table on page 3, we should gather that three never qualified for the position, and as they never received any directors' fees, there is nothing more to be said with regard to them. Of the others, Sir John Stokes had 51 ordinary shares, and received over £694 in director's fees; Sir Rawson W. Rawson had 70 ordinary shares, and received £1,493 odd in director's fees; Sir Edwd. Thornton had 50 ordinary shares, and received £241 in director's fees. These are no doubt all estimable gentlemen, but no one, reading from what has since transpired, can for a moment doubt but that they were figureheads upon the Board, and we may assume the managing director and the board of directors for all practical purposes was Mr. F. L. Rawson.

The summary refers to the original prospectus and the subsequent prospectuses which were from time to time issued. We may quote the following paragraphs:

"The official receiver has examined the profit and loss account of Woodhouse and Rawson, Limited, on which a profit of £21,440 is represented to have been made for the year ending June 30, 1888, and discovers that a large portion of the profit arose by reason of the assumed value of various interests in other companies. So doubtful was the real profit that the auditors prepared a special report, the concluding paragraph of which is as follows: 'The accounts are in accordance with the books of the Company, but it is obviously impossible for us to be responsible for the net profit, having regard to the nature of the assets and the Company's interest in many trading concerns not yet fully developed, and without Stock Exchange quotations of their shares.'

"A balance-sheet of Woodhouse and Rawson, Limited, as at June 30, 1889, and a profit and loss account for the year ending that date, were duly prepared, the latter showing an apparent profit of £78,222. 3s. 6d. The auditors do not appear to have been instructed to examine it until May of the succeeding year; their report is dated June 26, 1890, and the official receiver gathers therefrom that very grave doubts existed in their minds as to the reality of the profits, having regard to the sources (similar to those of the previous year) from which such profits were represented to be drawn.

"The official receiver has not seen the accounts in the liquidation of Woodhouse and Rawson, Limited (which commenced in September, 1889), and consequently has at present no means of informing himself precisely to what extent the said profits have been realised, but he believes it is the fact that a large portion of them was illusory, and it may be necessary hereafter to apply for an inspection of the said accounts. In this connection Mr. F. L. Rawson states that, although certain of the items treated as profit were not subsequently realised, the liquidators, on the other hand, received considerably more for their interest in the Elmore companies than was taken credit for.

"The businesses were taken over as from the 1st July, 1889; Woodhouse and Rawson, Limited (of which company the then directors and subsequent liquidators are stated to have been Sir John Stokes, K.C.B., Mr. Frederick Ashby, Mr. Albert Hoster, Mr. T. H. Lambert, and Mr. F. L. Rawson) were the promoters, and it is said that there were no intermediary vendors or profits. The expenses of the promotion and formation were paid by Woodhouse and Rawson, Limited, and are stated to have amounted to about £10,000.

"All the businesses are stated by Mr. F. L. Rawson to have been profitable prior to the amalgamation, with the exception of the Woodhouse and Rawson Electric Manufacturing Company, and the Woodhouse and Rawson Electric Contract and Maintenance Company.

"Mr. F. L. Rawson was connected in the capacity of a director with all the businesses except that of C. L. Baker and Co., Limited."

The terms for which the businesses were acquired are set out in detail. The total price as per agreement was £269,000, of which £109,778 was in cash, and the balance in debentures and ordinary and preference shares. A very important reference states that some of the vendors' shares were subsequently sold at prices varying, it is stated, from par to £2 by the persons to whom they were allotted. The valuation of the assets taken over for this amount, £345,230, but of this no less a sum than £159,265 was for patents, and £97,000 for goodwill. The summary then goes on to analyse more in detail the various issues for capital, and tabulates five other businesses which were acquired at a purchase price of £41,000, payable £15,929. 10s. in cash, the rest in debentures and preference shares.

Then follows a summary of the various balance sheets put forward by the said Company, with an analysis of these balance-sheets. Of that for the year ending June 30, 1890, the following paragraphs on page 11 speaks:

"Having regard to the facts above mentioned, it will be a matter for further consideration: (1) Whether the

directors were justified in treating certain of these profits as earned and divisible instead of placing them to a suspense account, pending the development of affairs? (2) Whether Mr. F. L. Rawson was entitled to be credited with the full amount of £13,775 above mentioned? (3) Whether the facts were fully before the shareholders when they consented to part, as hereafter mentioned, with the guarantee fund?

"As bearing upon these points it has to be kept in mind that the International Okonite Company was only registered in June, 1890, and its prospects could therefore only be conjectured when the balance-sheet and profit and loss account were prepared."

The remarks as to the balance sheet for the year ending July 31, 1891, may also be quoted in full, as may also the remarks on the profit and loss account.

"ACCOUNTS FOR YEAR ENDING JULY 31, 1891.

"(1) *Balance-sheet*

"It will be observed that during this year the dividend guarantee fund disappears from the Company's balance-sheet, it had previously ceased to be represented by specific securities. This alteration was effected at a meeting of shareholders held on January 9, 1891, when it was represented that the Company had attained to such a flourishing state that the retention of the fund was not necessary for the purpose required, the prospects as regards the payment of future dividends being quite satisfactory. In consideration of obtaining a settlement at the time, the vendors, who are said to have proposed this arrangement, offered to forego the purchase money to the extent of £12,000, and the shareholders, evidently being satisfied as to their position, and fearing their inability to pay the whole amount in cash in July, 1892, agreed to a settlement on these terms, the balance of the purchase-money (£63,000) being paid as to £12,278 in cash, and as to the remainder (£50,722) in 5½ per cent. debenture stock.

"In view of the Company's subsequent history, it is to be noted here that although the dividend guarantee fund of £75,000 was lying in the business without interest, a portion of it (£50,722) under this arrangement became immediately chargeable with interest at 5½ per cent., under which circumstances the rebate of £12,000 has been at least a doubtful advantage.

"The item 'sundry investments,' was made up of the following items:

	Value as per balance sheet.		
Austrian Elmore shares	£5,842	10	0
Foreign Elmore founders' shares	125	0	0
French Elmore shares	625	0	0
Austrian Elmore debenture stock	6,451	0	0
International Okonite debentures	26,000	0	0
" ordinary shares	11,696	0	0
" preference shares	5,255	5	0
Ward Electrical Car Company shares	2,000	0	0
French Elmore debenture stock	1,000	0	0
Sociedad Espanola shares	9,699	0	0
Epstein securities	35,145	0	0
Shares in Phœnix Trust Company	15,000	0	0
Debentures in J. and G. Thompson, Limited	500	0	0
	£119,338	15	0

"(2) *Profit and Loss Account.*

"The sum of £4,156. 19s. 9d. was written off patents.

"The 'gross income' includes the following items:

"(a) Premium on shares, etc., £3,933.

"(b) A sum of £14,975, being the assumed appreciation on shares in the Phœnix Trust Company. This latter company engaged with Woodhouse and Rawson United, Limited, to become responsible for the flotation of the French Elmore Company, and afterwards of the Austro-Hungarian Elmore Company, and later the American and Canadian Elmore Company. Woodhouse and Rawson United, Limited, promoted the companies; the Phœnix Trust agreed to underwrite the shares, and was, in fact, a company formed specially to work in conjunction with Woodhouse and Rawson United, Limited, in these matters. Mr. F. L. Rawson was one of the directors of the Phœnix Trust Company.

"In order to secure an interest in the profits of under-*writing*, the Company took 25 founders' shares in the Phœnix Trust Company, for which they paid £25. When the profit and loss account was made up, this asset was written up to the amount of £15,000, and the balance of £14,975 carried into profit and loss account. The reasons for this large appreciation have been furnished by Mr. F. L. Rawson to the official receiver; the Phœnix Trust Company went into liquidation in December, 1892. The interest of the Company in the Phœnix Trust Company still stands at £9,156 in the books, now only estimated to produce nil.

"(c) £12,000, the rebate received in respect of the repayment of the dividend guarantee fund.

"(d) A sum of £35,145, treated as profit, on the promotion of the Epstein Accumulator Company, the whole of which existed merely in the shape of securities of that company, which were then and still are, except as regards a trifling amount, unrealised. The position of the Epstein Company was then such that the value of its securities could only be conjectured; they are now estimated to produce £17,022. Mr. F. L. Rawson became a director of this company, which has never paid any dividends, and as to which some further information is given.

"(e) £2,000 for services rendered in the promotion of the Ward Electric Car Company, the whole of which was represented by 1,000 fully-paid £10 shares, represented to be of the value of £2 each, of which 750 are now estimated to produce £375.

"(f) A sum of £1,111. 13s. 9d. being the assumed profit in respect of the receipt from the Sociedad Española of 3,233 shares, which the Company valued at £3 per share, in settlement of a debt for work done, etc., of which the prime cost was £8,587 6s. 3d. (invoiced at £9,699). As will be observed hereafter, these shares are now estimated to produce £1,616.

"(g) A sum of £2,640, being an assumed profit in respect of certain assets acquired from Messrs. King, Masterman, and Terry, which were estimated as of greater value than the amount paid for them.

"(h) A number of shares in the French Elmore Company were handed over to the Company by the Phœnix Trust Company as their share of profits on the promotion, but the amount subsequently realised from the sale of them cannot be readily ascertained from the books. The French Elmore Company has paid no dividends, and is at present in liquidation, but a scheme of arrangement is under consideration.

"(i) £5,000 paid by the Phœnix Trust Company as the profit of Woodhouse and Rawson United, Limited, on the formation of the Austro-Hungarian Elmore Company. This amount consists of 2,000 Austrian Elmore shares, estimated at £2. 10s. each, of which company's shares the Company now hold 2,337, estimated to produce £584. Subsequently the Company received as commission on the sale of German Elmore patents £4,588 in Austrian Elmore 6 per cent. debenture stock, which was estimated at par, and is now estimated to realise at 50 per cent. discount. The Austrian Elmore Company has paid no dividends.

"The 'net profits' amounted to £35,103. 9s. 2d., which, together with £16,335. 15s. 3d. brought forward from the previous year, left an apparent sum of £51,439. 4s. 5d. for the directors to dispose of. A dividend of 8 per cent. on preference and 15 per cent. on ordinary shares was again paid for the year, and absorbed £31,408. 16s. 10d., in addition to which the reserve fund was increased by £10,000, the bad debt reserve by £1,500, and the employés pension fund by £500.

"The accounts for this year will also form the subject of further enquiry, particularly in connection with the question whether the directors were justified in declaring dividends out of profits which could only be estimated and were in such a large degree unrealised.

"The auditors' certificate on the accounts for this year stated that 'the amounts taken credit for, for plant, stock, and works in progress and investments not quoted, have been certified by the Company's officials.'

"Notwithstanding the alleged prosperity of the Company as described in the annual reports, it is the fact that about this time the directors found it necessary to have recourse to borrowing moneys for the purpose of carrying on the Company's business. Some particulars of the loans are as follows: (1) In December, 1890, £8,500 was borrowed

from the Empire of India Corporation to pay part of the purchase-money to Woodhouse and Rawson, Limited. The sum actually received from the corporation was £7,960. (2) In April, 1891, £10,000 was borrowed from Mr John Wood, at 7 per cent. (3) In February and March, 1891, £20,000 was borrowed from Martin's Bank, at 6 per cent. interest and 5s. per cent. commission. (4) During April and May, 1891, the directors borrowed further sums from their bankers amounting to £11,000 at rates varying from 6 per cent. to 6½ per cent., and on July 2, 1891, £10,000 at 7 per cent.

"The following loans were contracted between July 31, 1891, the date of the balance sheet, and November 13, 1891, the date of the general meeting at which the accounts were presented and the dividends approved –viz : (1) On September 9, 1891, £25,000 from the Founders' Stock and Share Trust at 7½ per cent. ; (2) on October 23, 1891, £10,000 from Martin's Bank at 6 per cent.

"Since November, 1891, the directors have found it necessary to continue borrowing, in some cases at a very high rate of interest.

"The dividends paid for this year (to July 31, 1891) were the last that the Company has paid ; the dividend guarantee fund has therefore, notwithstanding all the representations regarding it, proved a very deficient protection to the shareholders."

The accounts for the year ending July 31, 1892, showed the utter rottenness of the whole concern. During the two preceding years 8 per cent. had been paid on the preference shares and 15 per cent on the ordinary shares The dividends, as will be seen by the remarks quoted, were hardly justified had the accounts been made up on a better business footing. The third balance acknowledges special losses amounting to £69,531, and the net loss for the year amounted to £129,764. 11s. 5d.

We should have liked to have given this damaging document in full, but must forbear. The statement of affairs, according to the official receiver, was very much delayed, and no adequate reason has, in his opinion, been assigned for this delay. The summary of the statement of affairs shows that the gross liabilities are over £212,000, and the assets are so estimated as to show 20s. in the pound on this amount, with a total deficiency as regards contributaries of £448,321. 7s. 11d. ; in other words, this managing director, or directorate, in the course of a little more than a couple of years has by some means or other –it can hardly be called business operations—got rid of that large amount.

THE DEVELOPMENT AND TRANSMISSION OF POWER FROM CENTRAL STATIONS.*

BY PROF. W. CAWTHORNE UNWIN, F.R.S.

LECTURE VI.

(Concluded from page 569.)

When the Niagara Commission met in London, two years ago, there was, the author believes, only a single installation in Europe where power was developed and distributed electrically for motive-power purposes to many consumers. That was the interesting work carried out by Messrs. Cuenod, Sautter, and Co., of Geneva, at Oyonax, in France Turbines of about 250 h.p., at Charmines, generated a continuous current at 1,800 volts, which was transmitted eight kilometres by overhead wires to Oyonax There the current was reduced by motor transformers and distributed, partly for lighting, partly for driving motors in a number of small workshops. Nothing could appear more prosperous than this village when the author saw it in 1892. But at that time only about 30 h.p. was distributed for motive-power purposes, and about 40 h.p. for electric lighting. About that time the Schaffhausen installation began working, which was described fully by Mr Gisbert Kapp. That plant was delivering last year about 500 h.p. to one spinning mill. Probably now the power is more widely distributed A very interesting transmission was erected by M Hillairet, at Domene, near Grenoble. A turbine of 300 h.p. drives a dynamo at 240 revolutions per minute. This transmits a current at 2,850 volts by an overhead line a distance five kilometres to a paper mill In the mill is a motor of 200 h.p. running at 300 revolutions. The total efficiency of dynamo, line and motor is 65 per cent.

All the three installations just described have three features in common. The electric current is a continuous current, it is conveyed by an overhead wire, and the source of energy is water power.

Very probably, in future, alternating currents will replace continuous currents for distant transmissions. It has been decided to use alternating currents, simple or of two phases, for the transmission from Niagara to Buffalo. Alternating current dynamos are free from some of the insulation difficulties which have to be encountered in continuous-current machines, and can be worked probably at tensions impossible for continuous current machines. If motors for alternating currents can be made simple and self-starting, like continuous current motors, then the facility of transforming the voltage of the current in a purely statical transformer is an advantage which will give alternating currents a superiority in long distance transmissions. But here again the cost of transformers is a not unimportant factor in determining the feasibility of a transmission. Probably it is only where water power is available, and in most cases only where cheap overhead transmission is possible, that electricity can be supplied at a cost permitting it to compete with other sources of power.

Electric Distributing Mains.—In all distributions of electricity for power purposes to a distance hitherto carried out, except some mining installations, bare conductors carried on wooden telegraph posts have been used In cases like that at Oyonax, where the line is carried over fields to a small village, such a cheap method may be used without much objection, even when high tension currents are transmitted In that case, however, there is a liability to injury, especially to injury from frost and from lightning, which must be reckoned with. It is fair to point out that when the cheapness of electrical transmission is put forward as a reason for adopting it in preference to other methods of transmission, it is almost always assumed that such rough and cheap expedients as an overhead conductor on telegraph posts can be adopted. To a mechanical engineer such arrangements do not appear to afford adequate security or permanence for an important power distribution. In proportion as the number of consumers taking power from a common source becomes greater, the inconvenience and damage resulting from any stoppage of the supply of power becomes more serious Hence it will probably prove to be necessary, if any general system of power distribution by electricity is carried out, to place the conductors in subways where they are protected from injury Such a construction, however, will necessarily increase the cost of electrical transmission

The smallest self respecting town requiring a water supply would not hesitate to build such a concrete conduit as that shown in Fig. 31. D'Arcy built such a conduit 13 kilometres in length for

FIG. 31.

the water supply to Dijon. It is the smallest conduit accessible throughout. An important electrical power distribution needs permanent and secure construction as much as a system of water supply. An objection is sometimes made to a subway for bare conductors carrying high tension curents that there would be danger to life in traversing the conduit. To obviate danger as far as possible, the conductors have been placed in recesses. Further, by movable metal screens put in connection with a return or earthed conductor, any part of the conduit could be made absolutely safe while repairs or alterations were in progress. The figure shows, of course, only a sketch of a possible arrangement, but some permanent protection for conductors will have to be adopted in important electrical distributions.

The Herstal Installation.—In 1886, the manufacturers of small-arms in Belgium formed a syndicate. To carry out a large order, the society decided on the erection of new workshops with tools of the most modern construction. M Leon Castermans has given an account in the *Revue Universelle des Mines* of the development of the plans of the works and of the reasons which led to the adoption of electrical transmission.*

The operations to be carried on involved the construction of a number of different factories more or less distant, and so arranged as to be capable of future extension. In these factories it was found necessary to arrange for 13 lines of shafting carrying a total

* Howard Lectures delivered before the Society of Arts.

* *Revue Universelle des Mines*, xix. 1892.

of 200 effective horse-power, or allowing for loss in transmission and engine friction, 300 i.h.p. Electric lighting was next decided on, and for this an additional 100 i.h.p. was required.

It now became a question of driving the different lines of shafting from the steam engine, and for this some system of transmission had to be selected. The mechanism between the steam engine and the lines of shafting and belting in the workshops, from which the tools are directly driven, may be termed the intermediate transmission. The arrangements of this transmission are required to subdivide and distribute the motive power, and to effect such modifications of velocity as are necessary. In this intermediate system a gradual subdivision of power must be carried out, involving, if ordinary mechanism is employed, a waste of power at each step of the process. The aggregate of these losses is large. It is a special inconvenience of any mechanical system of transmission that no part can be disengaged from the transmission without the use of more or less costly and cumbrous appliances, and hence, practically, when all the machines are not running, a good deal of the transmission is kept running uselessly. Hence, the waste of work which the transmission occasions when running at full load, is largely increased when only a part of the tools require to be driven.

Two systems of intermediate transmission were first studied—a system of shafting, gearing, and belts, and a system of rope transmission. It was found that the moving part only of the intermediate transmission would weigh 40 tons besides 30 tons of pedestals and other supports. Practically, the whole of this would be constantly running, occasioning frictional loss and requiring attention and lubrication, whether much or little work was done.

There is a further inconvenience of such systems indicated by M. Castermans. They do not easily lend themselves to extensions of the works. Either they must be made of excessive size at first, or, when an extension is necessary, they must be removed and replaced by a new transmission.

The study of the waste in ordinary systems of transmissions to such a group of workshops, led to the consideration whether the mechanical intermediate transmission could be replaced by electric transmission, with separate motors to each principal line of workshop shafting.

It was estimated that 260 effective horse power were required on the 13 lines of shafting. To cover contingencies, motors of an aggregate of 200 h.p. were selected, and, allowing for the loss in these motors, it was estimated that 297 h.p. of electrical energy would have to be transmitted to them. That required a dynamo taking 336 h.p. at the crankshaft of the engine, or 360 i.h.p. The effective work on the driving shaft of the machines is therefore 72¼ per cent. of the indicated work of the engine at full load.

The electric system, then, has these advantages: (1) Simplicity in the transmission between the engine and secondary motors by conductors instead of by shafting and gearing; (2) saving of loss in running an intermediate system of transmission constantly, whether much or little work was being done; (3) greatest efficiency of transmission, even with full load; (4) facility for effecting future extensions with the smallest modification of existing plant.

The system has been carried out very successfully. A steam-engine of 500 h.p., built by Van den Kerchove, running at 66 revolutions per minute, drives the armature of a single dynamo keyed on its crankshaft. This armature serves as the flywheel of the engine. There are two commutators each taking half the current. The maximum current is 2,440 amperes at 125 volts.

The secondary motors, which drive each a line of shafting, are two-pole motors, with Gramme ring armatures and carbon brushes.

The Herstal plant has been entirely successful, and there is no doubt that the distribution of the motors, which saves a number of intermediate transmissions, must lead to economy of motive power. But it is fair to point out that this problem of distributing the motive power of large works did not first arise at Herstal, and can be solved with similar advantages in other ways. It has always been a question, where steam power is used, whether it is desirable to concentrate it in a single engine or to work with each principal line of shafting driven by a separate engine. In dockyards, distribution of power by pressure water or compressed air has long been practised from precisely the same motives as those which influenced the engineers at Herstal. In some large works gas engines, distributed at various parts of the works, are being adopted to replace the single steam engine and complex intermediate transmissions previously in use. At Seraing, for 20 years there has been a distribution of power by compressed air, working motors on individual machines. At Birmingham, in several factories, air motors, involving as little trouble as electric motors, were used to drive small divisions of the machinery, and a large amount of shafting previously in use was removed.

Electric Transmission for Mining Work in Nevada.—An interesting case of the transmission of power electrically is that at the Comstock Mines, Nevada. There existed at the mines a 10ft. Pelton wheel driven by water supplied under a head of 460ft. and furnishing 200 h.p. To obtain additional power the water from this wheel is conducted by two iron pipes down the vertical shaft and incline of the Chollar mine to the Sutro tunnel level. It is there delivered at a pressure of 680lb. per square inch, equivalent to 1,630ft. of head, to six 40in. Pelton wheels. The jet to each wheel is only ⅝in. in diameter, and each wheel developes 125 h.p. at 900 revolutions per minute. Each Pelton wheel is coupled to a Brush dynamo, generating current, which is led to the surface, where it drives by dynamo motors a 60-stamp mill. The Brush motors revolve at 850 revolutions per minute. Of 700 h.p. developed by the Pelton wheels, 435 h.p., or 60 per cent., is said to be delivered at the motors. The Pelton wheels weigh only 1·8lb. per electric horse-power.

The Genoa Installation.—Exceptional circumstances have made it possible at Genoa to establish an electric supply in connection with a water supply. Some 10 or 12 years ago works for supplying water to Genoa, additional to others then in operation, were constructed. The water is obtained from streams on the Piedmont Liguria frontier, and two large impounding reservoirs have been constructed on the Gorzente River, an effluent of the Po. The reservoirs are 2,050ft. above Genoa, there being a large surplus fall not required as head for the water supply. To relieve the pipes of unnecessary pressure, three relieving or service reservoirs were constructed, reducing to about 600ft. the pressure available for the transmission of the water to Genoa. The first reservoir is near the outlet of a tunnel by which the water is carried through a mountain ridge, and is 360ft. below the tunnel. At that point 730 gross horse power are utilisable. The second reservoir is 360ft. below the first, and there also 730 gross horse power can be obtained. The third reservoir is 500ft. below the second, and there 1,000 gross horse power can be obtained. The water supply scheme has not been entirely successful, and the engineer, M. Bruno, and the consulting engineer, M. Prove, were led to consider the utilisation of the surplus fall to generate electricity, to be transmitted for lighting and power purposes to Genoa, distant about 16 miles.

At the three points described, electric generating stations, named after the Italian electricians, Galvani, Volta, and Pacinotti, are now in operation.

A first installation of a turbine of 140 h.p. was made in 1889, at the Galvani station. This proved successful, and the further development of the stations was undertaken. The Volta station supplies electricity to 15 motors distributed along the valley from Isoverde to Genoa, and to a motor of 60 h.p. at the railway station in Genoa. It also supplies motor transformers at the central electric lighting station in Genoa. The remainder of the power at this station, amounting to 600 h.p., is utilised by means of telodynamic transmission. The Volta station supplies electricity for lighting the station of Sampierdarena by a motor of 60 h.p., driving 12 Siemens and two Technomasio dynamos, and also supplies electricity for motive power to a number of mills and factories and the repairing shops of the railway. Messrs. Cuenod, Sautter, and Co., of Geneva, who constructed the electrical plant, have furnished the following details. Messrs. Rieter Bros., of Winterthur, constructed the first turbines erected. The remainder have been constructed by Messrs. Faesch and Piccard, of Geneva.

Electrical System.—The distribution is in series at constant current. The generating dynamos maintain a current of constant intensity in a single circuit which traverses all the motors. They supply a constant number of amperes whatever the number of motors at work. The voltage is essentially variable. At certain hours all the motors are out of action. Then the dynamos furnish a current at 450 or 500 volts corresponding to the loss in the circuit. At certain hours both the motors supplying power and the motors driving dynamos for lighting are in action. Then the voltage reaches 5,000 to 6,000 volts.

Galvani Station.—This has a single group of machines, consisting of two Thury continuous-current dynamos, coupled by Raffard couplings to a Rieter turbine of 140 h.p., having a normal speed of 450 revolutions per minute. In addition, a jute factory absorbs the power of two Rieter turbines of 300 h.p., the power being transmitted to it by telo-dynamic cables. The generators have six poles, and give at full load 47 amperes at 1,000 to 1,100 volts. Their speed varies from 20 to 475 revolutions per minute according to the demand for power. The dynamos are coupled in series, and work day and night.

Volta Station.—This has been in operation since 1891. There are four turbines of 140 h.p. each, and eight dynamos working at 47 amperes and 1,000 volts at full load. These generators work at constant speed, and the regulation is effected by varying the exciting current. The regulation is effected by a single regulator, however, many generators are in action. The main turbines are Faesch and Piccard turbines with relay governors, which maintain a strictly constant speed.

The regulation of the exciting current involves difficulties, because the voltage of the main circuit must vary from moment to moment, and sometimes quite suddenly, when motors driven by the current are thrown out of action. The motors are thrown out instantly by short-circuiting them. To meet these conditions, the exciting dynamo is driven by a separate 15 h.p. turbine, which has as little inertia as possible. The exciting dynamo has a very light armature, so that it follows instantly the variations of speed of the turbine driving it. The exciting dynamo is itself excited by a small machine serving to light the station, and the stability of its magnetic field is thus independently secured. The turbine driving the exciting machine is provided with a relay governor, but the conical pendulum, ordinarily used to secure constant speed, is replaced by a solenoid holding in equilibrium a soft iron core weighing 33lb., which is directly attached to the valve of the relay. A leather belt keeps this core and the valve in rotation, so as to practically annul any frictional effect. A spring and counterweight permit the adjustment of the action of the regulator. The solenoid is traversed by the current in the main circuit, which is normally 47 amperes. If the current augments, the core of the solenoid rises, puts in action the relay, and closes the sluices of the turbine driving the exciter. *Vice versa* if the current decreases, the relay opens the turbine sluices.

The system Messrs. Cuenod and Sautter state has given good results. Nevertheless, at the third, or Pacinotti, station, a return has been made to the system adopted in the Galvani station. The regulation is effected by varying the speed of the main turbines, which are constructed with as little inertia as possible, and have no speed regulators.

The Transmitting Arrangements.—The current is transmitted by bare copper wires, ¼in. in diameter, carried overhead on poles, with porcelain and oil insulation. The greatest distance of transmission is 30 miles. The line has a resistance of about 500 volts, or an efficiency at full load of 90 per cent.

The Motors.—The motors are all Thury motors, and are from 5 h.p. to 60 h.p. From 5 h.p. to 18 h.p. they are bipolar. Their regulation is effected by shunting, more or less, of the current, and they are all placed in series. Larger motors are multipolar, and these are regulated by displacing, more or less, the points at which the current enters and leaves the motor. This has the effect of reducing the magnetic field by causing some of the convolutions to be traversed in a direction reverse to the normal. Each motor is governed by a relay, and has a flywheel. A lever and counterweight is provided to adjust the governor.

The ratio of the effective work at the motors to the effective work of the turbines is stated to be 72 per cent.

Transmission at Biberist, near Soleure.—Messrs. Cuenod, Sautter, and Co. have also carried out a power transmission between Ronchatel and Biberist. Turbines of 360 h.p. have been erected, and the power is transmitted 28 kilometres to a paper mill. The generating station has two Thury continuous-current dynamos coupled to the turbines by Raffard couplings, and running at 275 revolutions per minute. Each dynamo gives a current of 3,300 volts, and the two dynamos are coupled in series. The current is transmitted by a bare copper wire, ¼in. in diameter, on simple porcelain insulators. The receiving station has two dynamos similar to the generators, making 200 revolutions per minute, and driving directly by Raffard couplings the machinery of the mill. An efficiency of 70 per cent. is guaranteed.

The Lauffen-Heilbronn Transmission.—The single case known to the author of the use of alternating currents for motive power distribution is at Heilbronn. The owners of the Wurtemburg Cement Works at Lauffen on Neckar, having surplus water power, conceived, in 1879, the idea of utilising it to supply electricity in Heilbronn, some six miles distant. They accepted plans for using the three-phase current. The Lauffen generating dynamo runs at 4,000 amperes and 50 volts. The voltage is changed to 5,000 by a transformer for transmission to Heilbron, and then reduced to 1,500 for distribution. Part of the current is further reduced to 100 volts in a network for lighting. The charge for current for lighting is 9d. per kilowatt hour. Current used for motors for industrial purposes is charged at 4d. per kilowatt hour, or about £42 per effective horse-power year of 3,000 working hours. This is for current alone, exclusive of interest on the cost of motors. In November last there were on the system 11 motors aggregating 32 h.p., a rather insignificant motive power distribution. So far as the author has had opportunity of judging, the three-phase system with double transformation is an expensive method of distribution. It is worth noting that Mr. C. E. L. Brown, who designed the Lauffen dynamo, speaks doubtfully as to the system. He says that one object of the Lauffen-Frankfort experiment was to show the advantages of the three-phase system for power distribution. But that it actually showed the disadvantages of the system—viz., complication in line, generator, and transformers.

INSTITUTION OF ELECTRICAL ENGINEERS.

DISCUSSION ON PROF. FORBES'S PAPER.

(Concluded from page 565.)

Mr. Alex Siemens thought it only right to the commission that asked for tenders that he should explain the conditions under which they were invited. Perhaps Mr. Ferranti, who had complained about the policy pursued, did not know what those conditions were. When he (the speaker) had the pleasure of speaking with the president of the commission the latter mentioned to him that the various competitors were to hand in competitive designs, and that the commission was to supervise the construction of the machines in America. His firm competed, but did not send in any detailed designs, and in consequence they were excluded from the prizes. Anyone who had read the conditions could see from the beginning that the intention was to construct the whole of the machinery in America. He agreed with Mr. Ferranti that the prizes of £200 to £500 were inadequate. No question ought to arise about sending the current along cables at 20,000 volts. His firm had used a concentric cable which had carried 24,000 volts, and since then it had been used in experiments with current at 50,000 volts, and occasionally up to 60,000 volts, and there had never been anything wrong with it. They had found that the continuous current was the best for the purpose, and he was not sure that the Cataract Construction Company would not ultimately be converted to the use of the continuous current.

Mr. S. Evershed submitted in connection with the subway that a point of great importance would be the induction between the conductors, whether solid or laminated. Another point was that of coupling the machines in parallel. He desired to know the utility of an artificial load when coupling in parallel. He had never seen such an arrangement in England, and he wanted to be informed as to what advantage Prof. Forbes regarded as obtainable by using an artificial load in exciting machines in parallel.

Mr. R. E. Crompton said there had been an important omission. As far as the interest of the paper was concerned, it was like "Hamlet" with a part left out. If the paper was anything, it was a first attempt to describe a large commercial undertaking of transmission of power. The whole question was one of £. s. d.: what would be the cost of power at Buffalo, and how would it compete with the cost of steam power in that town. There was nothing in the paper which gave them any information on this head. The questions of the E.M.F. to be employed, whether continuous or alternating current, periodicity, etc., were, no doubt, of great importance, but they were subsidiary to the question of what could be done with a given capital, what the cost of the energy would be, and what the interest on the money spent would be. That was a factor about which they must know something before discussing the scheme. He, in common with many other engineers, had considered similar though smaller schemes, but they had been obliged to abandon them, as the interest and the cost of the plant were so great as to overwhelm the advantages of using water power. The barefaced attempt to pick the brains of the world, and then utilise it for the benefit of the manufacturers, was a thing to be admired! He was sorry to say it was even carried out in this country. He spoke feelingly. The Americans had only done on a large scale what so many around them in this country were doing. Theoretically, continuous currents were the best for the job. The recent explosion in the French Chamber would be very small as compared with that of an arc starting in the subway, and which, as Mr. Ferranti had remarked, would go to the other end. He wondered whether Prof. Forbes had made any experiments as to the insulating power of porcelain. Very great failures had taken place where the overhead material had been used for underground work. The result had been that they had made great improvements, and had now got material which carried 200 volts. If material could be obtained to carry 20,000 volts that was beyond his comprehension. Oil insulators were supposed to be of utility, but after a time they proved to be entirely useless. He did not agree with Mr. Ferranti that 42 periods were sufficient for electric lighting. He had seen many of the Ganz stations working at 42 periods, and the arc lighting was disgraceful, and when Messrs. Ganz and Co. were in competition with any other company they lost the arc lighting work.

Mr. Mavor, who had during the past year been carrying out work in connection with culverts, observed that it would have been interesting if the author had mentioned how the subway was to be ventilated. The question of the variations of the atmospheric conditions must be very difficult. He considered that the method of drainage was insufficiently described.

Major-General Webber said they ought to remember that the author had brought before them a paper referring to work that had not yet been carried out, and that modifications would have to be made in carrying out the work. They ought not to forget that Prof. Forbes had given credit to those who had given him advice. Very few consulting engineers would have ventured to give them a description of works that had only been designed.

Mr. C. E. L. Brown (whose remarks contained in a letter were read by Mr. Kapp) said that he had come to the conclusion that a higher frequency than that adopted by Prof. Forbes would have been better. It was astonishing that so much was still said of the difficulty of running alternators, single or multiple, in parallel. He had run machines in parallel under the most difficult conditions, and had never found the slightest difficulty. He had come to the conclusion that the coupling of alternators in parallel was as easy, if not easier, than that of direct-current machines. Mr. Brown had never found an artificial load necessary. With regard to the transformers, there was no doubt that a high frequency was best. He pointed out that it was far more difficult to design a large transformer to run cool than a small one. Dealing with the question of motors, they could be constructed of suitable design to give as good results with high frequency as with low. In connection with incandescent lighting, it was advisable to be well above 30 periods, and for arc lighting not less than 40. Single-phase motors were now on the market. Considering the number of designs sent in, it was surprising that Prof. Forbes should have decided upon the worst arrangement possible for his machines.

Prof. Forbes, in reply, said that the discussion had hardly maintained the position of the Institution and of the capability of its members to discuss a large and important problem. He attributed this to their not having had sufficient time to study the question in all its bearings. With regard to low frequency, he was astonished that men like Mr. Mordey, Mr. Kapp, and Mr. Swinburne were incapable of realising its benefits, and he felt sure that they would be converted to his views on further thought, just as the International Commission was with respect to alternating currents. He regretted that certain accusations had been made against the Cataract Construction Company and its international commission, but the scheme which had been accepted was his own, and he was perfectly satisfied with the loyal manner in which the Cataract Construction Company had carried out their obligations. In 1890 he had given them a report with detailed drawings and estimates, urging the use of the alternating current—that it should be generated in two phases; that 2,000 volts was to be used for the local work, and transformers to raise the pressure for transmission to Buffalo; that the motors were to be synchronising motors, Tesla two-phase motors, and motors with laminated fields and commutators. The only mistake made in that report came from a desire to use machinery then on the market, for which reason Mordey alternators were recommended. They knew now that their high frequency, and other features, rendered them unsuitable. Dr. Fleming's remarks were a redeeming feature in the discussion. He had realised thoroughly that "the advantage of adopting a low frequency and low capacity is something enormous," and that "there can be no doubt about the wisdom of the choice of selecting this low frequency for a case such as the Niagara transmission." Prof. Forbes considered that this, coming from a man who had the [illegible] experience [illegible] as a warning, must be looked on as a statement carrying the greatest

weight. Mr. Mordey and others who spoke about the lighting as being an important feature, had evidently no idea of the character of the work; and Mr Mordey's criticisms with regard to small lighting transformers had no bearing on the large transformers required for Niagara Falls, where there was no difficulty in getting much higher efficiencies than those quoted by Mr. Mordey. With regard to parallel working, Mr Mordey had said: "If 100 periods succeeds, why go to 25 periods?" He (Prof. Forbes) considered that this gave the idea that Mr Mordey's high frequency alternators worked perfectly in parallel He claimed that they did not, and quoted experiments, made with Mr Mordey, to prove this He also alluded to the breakdowns which Mr. Mordey had had in parallel working, and said that the Cataract Construction Company could not afford to have such experiences; and it was for the same reason that he wished to use an artificial load, so as to introduce every safeguard that could be devised especially as they were found necessary for efficient parallel working at Tivoli Mr Mordey thought that the Hughes effect would not be sensible but he had not realised what large masses of copper were required for carrying the huge power to be dealt with. Both Mr Mordey and Mr Kapp placed motors in the list of things that did not support the reduction of frequency, but they had given no evidence, whereas he had given experimental proof and theoretical explanations to the contrary. Mr Mordey's proposals to use 500 volts in the dynamo was utterly unpractical, as the transmission of 50,000 h p would require 400 square inches of copper Mr Kapp had made an erroneous estimate of the copper required in different systems He (Prof. Forbes had had occasion to correct the erroneous argument as laid down by Prof Elihu Thomson, and he would publish the refutation with his reply. At the end of the paper a proof had been given that, in doubling the frequency of a polyphase motor, the losses in the field were increased 42 per cent Mr Kapp, while admitting the 42 per cent., claimed that the motor at higher frequency was giving 2½ times as much power He (Prof Forbes) referred to the drawings, and showed that in both cases the total number of lines of force was the same and cut the wires of the armature at the same speed, and therefore gave the same E M F. and current in the armature and the same power. If anyone but Mr. Kapp had raised these objections, he would have considered them beneath notice After pointing out errors in Mr. Kapp's view of the unsuitability of certain synchronising motors, he said he was pleased to find that Mr. Kapp approved so highly of the design which he had got out for the dynamos With regard to Mr. Ferranti's imputation that the Cataract Construction Company had got in designs from European manufacturers with the sole object of getting their ideas for nothing, he indignantly denied this, and assured the meeting that it would be impossible for him to act as consulting engineer to any company that did this With regard to Mr Ferranti's other imputation, that his (Prof. Forbes's design was borrowed from that of Mr Brown's he said there was more difference between his design and those of any of the manufacturers than between the designs of the manufacturers themselves, but Mr Ferranti's assertion was completely overthrown by the statement of Mr Brown's, just read, that his (Prof Forbes's design was the worst possible. With regard to Mr. Crompton's desire for a statement of the cost of producing a horse power, he had to say that, even when the works were completed, and the actual working cost made out, this was a piece of information that would not be likely to be given. After referring briefly to the remarks of some other speakers, he said that, while he regretted, for the sake of the reputation of some of the speakers, the remarks they had made without sufficiently considering the question, yet nearly every objection of one speaker had been answered by another. Not a single objection had been raised which he had not considered carefully while making his plans, and he felt a great deal fortified in all the conclusions he had arrived at by the character of the discussion, and he was more than ever certain of success in this great work.

PHYSICAL SOCIETY.

At a meeting of the Physical Society, held on the 8th instant, a paper by **Mr James Swinburne** on "**A Potentiometer for Alternating Currents**" was read by **Mr. Blakesley**. After referring to the many advantages of the "potentiometer method" of measurement, the author describes an arrangement by which alternating pressures can be measured. A quadrant electrometer with a double fishtail shaped needle suspended by a torsionless fibre is employed. The electrostatic attraction exerted by an alternating pressure between the needle and one pair of quadrants is balanced by the force due to a steady pressure between the needle and the other pair of quadrants. The magnitude of the steady pressure is determined by a potentiometer and standard cell, and the effective value of the alternating pressure thus deduced For measuring alternating currents a differential electrodynamometer, having two fixed coils and one moving coil and no controlling spring, is used. A direct current, measured by the fall of potential over a small resistance, is passed through one of the fixed coils, the alternating current through the other fixed coil, and the moving coil is included in both alternating and direct current circuits. When the two forces balance the currents are taken as equal. Several small inaccuracies to which the method is subject are mentioned in the paper. **Prof S. P. Thompson** enquired if the fishtail shaped needle of the electrometer was novel. **Mr. Blakesley** said the author had mentioned the needle previously. He (Mr. Blakesley) thought the name "potentiometer" was not very suitable. In effect, the so-called measurement of *pressures was a comparison of two powers.*

COMPANIES' MEETINGS.

SWAN UNITED ELECTRIC LIGHT COMPANY, LIMITED.

Directors J S. Forbes, Esq., chairman; W. Cuthbert Quilter, Esq., M.P., deputy chairman; E W. Batt, Esq, Major S. Flood Page, J. W Swan, Esq

Eleventh annual report of the Directors and statement of accounts for the year ending September 30 1893, presented at the ordinary general meeting of the Company, held at the Westminster Palace Hotel, Victoria street, S W, on Wednesday last.

The profit and loss account for the year shows a credit balance of £28,877 9s 6d., which, together with £6,824 17s. 9d brought forward from the last account, leaves disposable the sum of £35,702. 7s 3d. An interim dividend in respect to the first half of the year amounting to £9,376. 15s. 9d has already been paid The Board proposes that a further sum of £18,012 19s be divided, free of income tax, and that £8,312 12s. 6d be carried forward. The distribution of this amount in accordance with Clause 77 of the articles of association works out at 3s. 6d. per share on the 78,949 ordinary shares of the Company, £3 10s paid, and at 4s. 3d per share on the 19 750 £5 fully paid, being equivalent to 7½ per cent. per annum on the partly paid, and of rather less than 7½ per cent. upon the fully paid, shares The warrants will be issued on the 23rd December to the shareholders standing upon the register upon the 12th December instant. The shareholders may be reminded that Messrs Quilter and Swan were deputed to meet Sir John Lubbock and the Earl of Lichfield, acting for the Edison and Swan Company, with a view of suggesting a basis on which an amalgamation with this Company could be effected. This basis having been generally agreed upon, it became necessary to ascertain in the first instance whether the fully paid up shareholders of this Company are prepared to accept the terms Messrs Quilter and Swan have now by circular addressed each fully paid shareholder with a view of ascertaining whether they approve of the amalgamation of the companies on the arranged basis. As soon as this has been ascertained, the matter will be brought before the partly paid shareholders, and, if approved, a general meeting will be called to give effect thereto. The directors who retire by rotation are Mr W Cuthbert Quilter, M P., and Major Flood Page, who, being eligible, will offer themselves for re election. Messrs Welton, Jones, and Co, the auditors, will also retire, and will offer themselves for re election

PROFIT AND LOSS ACCOUNT, YEAR ENDING SEPT. 30, 1893.

Dr.	£	s.	d.
Stock, October 1, 1892	14,654	3	1
Purchases	2,915	16	5
Salaries, Directors' fees, rent, office expenses, income tax, general and law charges	2,783	7	2
Wages and expenses at factory	3,898	3	1
Balance	28,877	9	6
	£53,128	19	3

Cr.	£	s.	d.
Sales, less commission and allowances	10,346	18	5
Transfer fees and interest	646	4	7
Dividend on shares in La Compagnie Générale des Lampes Incandescentes, less tax	878	6	4
Dividends on shares in the Edison and Swan United Electric Light Company, Limited	24,826	4	4
Proportion of further dividends accruing to Sept. 30, 1893, on the above shares, estimated at	6,000	0	0
Dividends received and due on shares in the National Telephone Company, Limited	1,123	8	0
Balance of suspense accounts—law costs	800	0	0
Stock, September 30, 1893	8,507	17	7
	£53,128	19	3

BALANCE-SHEET, SEPT. 30, 1893.

Dr	£	s.	d.	£	s.	d.
Share capital – 19,750 shares of £5 each fully paid				98,750	0	0
78,949 shares of £5 each, £3. 10s. paid				276,321	10	0
				375,071	10	0
Sundry creditors				2,943	19	4
Balance from previous account	6,824	17	9			
Balance September 30, 1893	28,877	9	6			
	35,702	7	3			
Less interim dividend at the rate of 5 per cent. per annum for six months ended March 31, 1893, paid June 20, 1893	9,376	15	9			
				26,325	11	6
				£404,341	0	10

Cr.	£	s.	d.
Cost of patent rights, etc, represented by shares in Edison and Swan United Electric Light Company, Limited, with £298 478 paid; shares in La Compagnie Générale des Lampes Incandescentes with £30,489. 8s. 3d paid, patents held by the Company for Germany, etc., as per last balance sheet	328,563	12	4
Less amount over-estimated for legal charges	1,500	0	0
	327,063	12	4

Proportion of dividends accruing to September 30, 1893, on the above shares estimated at	6,000	0	0
Outlay on factory, plant, etc., as per last account	1,570	9	0
Sundry debtors	33,772	2	0
Stock on hand	8,507	17	7
Investment in 5,000 fully paid non-cumulative third preference shares in the National Telephone Company, Limited, cost	25,000	0	0
Cash on deposit and in hand	2,426	19	11
	£404,341	0	10

The eleventh ordinary general meeting of the Company took place on Wednesday at the Westminster Palace Hotel, S.W., Mr. J. S. Forbes presiding.

The **Chairman**, in moving the adoption of the report and accounts which are given herewith, apologised for the meeting being called at a later date than last year, but said he thought the reason would be regarded as satisfactory when he explained it. The Directors promised at the last meeting that measures should be taken with a view of combining the remnant of their business with the bulk of their investments in the Edison and Swan. The running out of the patents and the altered condition of things likely to arise when they were out of the influence of protection and in open and free dealings, no doubt made it desirable that their affairs should be as compact as possible, and managed as economically as possible. During the interval negotiations proceeded between the two companies, the Edison and Swan and the Swan, and had now reached that stage when, as far as the Directors were concerned, their responsibility would end, and that of the proprietors would begin. Briefly, what was the price which the Edison and Swan were to pay to the Swan shareholders for the remnant of their business not already included in the Edison and Swan? The Directors thought the better plan was that two gentlemen interested in the Swan Company and two interested in the Edison and Swan Company should have the necessary preliminary discussions and should if possible arrive at some basis of agreement, and that had been done. The matter was a good deal complicated by the relative position of the fully paid shareholders and the partly paid shareholders in the Swan Company. The Directors, therefore, begged Mr. Swan, who represented, for the most part, a holding in fully-paid shares, and Mr. Quilter, who represented more especially the partly paid shares, to put their horses together and to see what would be a fair method of dealing with the cake when they had it to cut. Of course, it had to be ascertained how big the cake was, the ingredients of which it was composed, and whether it would be palatable. That involved another process. Sir John Lubbock, although not a director of the Edison and Swan Company, was originally intimately connected with it, and was good enough, in conjunction with the Earl of Lichfield (a director), to consider the question from the point of view of purchasers. After rather prolonged negotiations, a basis had been arrived at, not only as to what the Edison and Swan was prepared to give for the residuum but as to how the purchase price was to be divided between the fully paid shareholders and the partly paid shareholders. The scheme was rather complicated, and it was not so easy to arrive at a conclusion, but the agreement arrived at seemed to be as equitable as was possible in a case where the factors were partly existing and partly problematical. Briefly, it was this. The Edison and Swan Company, in which they were interested to the extent of 60 per cent., agreed to give £100,000 in the shape of 4½ per cent. debenture stock, which, of course, would form a first charge over its whole income. The shareholders in the Swan Company would by that process put over their own heads £60,000 of 4½ per cent. debenture stock; their partners in the Edison and Swan would put £40,000. Dealing with the bargain, it was to be remembered that £100,000 debentures of the first charge was extremely safeguarded compared with the rest of the capital, because a debenture was a mortgage on the property, and the interest was cumulative. Assuming as they were obliged to assume the worst in such cases and assuming nothing to arise which would raise an issue as between the two classes of capital, it was quite clear that the one had a great advantage in respect of its priority, both for principal and interest, over the other. That consideration must not be disregarded in weighing the quantity. He himself had purposely abstained from entering too fully into the discussion until it was concluded, because a man could not be buyer and seller too, and as he would have to present this matter to the shareholders of both companies, if it was agreed to, it was absolutely necessary that he should keep out of the discussions, and, when the result was arrived at, examine it as nearly as he could from the point of view of an impartial judge. He had examined it, and, being conversant with the difficulties of dealing with the positive factor in conjunction with a factor more or less uncertain, he had arrived at a conclusion that it would be a very good bargain for both sides. First of all, it would put the two things under one umbrella; secondly, it would strengthen their hands as against the severe competition to which they were probably about to be subjected, both in England and abroad. It would also effect certain economies which would be extremely advantageous to the united body. With regard to the profit and loss account, the proportion of further dividends accruing to September 30, 1893, on the Edison and Swan United shares, estimated at £6,000, was brought in because the theory of the amalgamation was that the Company, with its liabilities and income, would be merged as from October 1 into the accounts of the Edison and Swan Company. Treating this as a winding up balance sheet, it was essential to bring that £6,000 into the account in order that there might be no mistake when the fusion took place. With regard to the dividends received and due on the shares in the National Telephone Company, there was a considerable amount of money invested in Consols paying a miserable rate of interest, and the Directors thought it wise, when the price of those Consols reached a figure at which they could be sold without loss, to get out, and put the money into some undertaking which would pay some reasonable dividend. An opportunity offered at that time to take shares which were about to be issued by the National Telephone Company, and, as Mr. Quilter and himself both knew something of the position of that company, they persuaded their colleagues to put the money into it as an investment which would return a reasonable dividend. On that £25,000 they had received 5 per cent., instead of 2¾ per cent. Referring to the law costs, the Chairman said that, unfortunately, ever since the initiation of the lamp business they had been more or less in litigation, and, as the solicitors did not send in their accounts to date, there was always a running account. The Edison and Swan and the Swan Companies in much of this litigation were partners, and it had only been recently by the submission of a final account on the part of the solicitors of those law costs, extending over several years, both in this country and in Germany, that it had been possible to state the account properly as between the two companies. The agreeable position in which the Swan Company found itself was this, that in the aggregate sums paid by the two companies the Swan had been debited with £2,300 more than was fairly attributable to it, but it had now got it back, and the account was clear. With regard to the stock, of which they must always have a large amount on hand, the £8,507 shown in the balance-sheet only represented the stock in Germany, to which their business was now exclusively confined by the agreement with the French company. In Great Britain the stock was much larger. It was a satisfactory result that they had been enabled during the year to September 30 to work that stock down from £14,654 to £8,507, and that had been done partly by disposing of it, and partly by writing down the value of it in the books as carried over. He thought the account was now in a most wholesome state. During the last few years the Edison and Swan Company paid on the face of the accounts very large dividends, but those dividends were made up of two elements: the 7 per cent. to which the "A" shareholders were entitled out of the profits of the particular year, and payment in respect to that 7 per cent. during the years when it was not earned. Last year, for the first time, they were enabled to wipe out the balance standing to the debit of that arrear, and to carry over a considerable sum of money which had to be distributed between the Edison and Swan "A" shareholders and the "B." But the dividend under those circumstances distributed was 10 per cent., and, in comparison with the dividend in the present year, showed £12,000 less than the money carried over in 1892, when the item of unredeemed arrears was so considerably greater. The share capital was exactly the same as last time, and they had been able to bring their business down to such a condition as to approach the almost perfect state in the accounts. Last year sundry creditors amounted to £5,000; but it was now reduced to £3,000, and, looking at the nature of the business, that was a small sum. That left £35,702 available. For the six months ended March, 1893, they paid an interim dividend amounting to £9,376, and it was now proposed to pay enough to bring up the dividend to 7½ per cent. That would absorb £18,012, leaving £8,312 to be carried forward. The sundry debtors amounted to £33,772, which was very satisfactory when the item sundry creditors was looked at, and which showed a surplus of debtors, all good, over creditors of £30,000. That was explained by the fact that the Company could not afford to let its money lie idle and was obliged to invest it. £20,000 were invested on Stock Exchange loans, that was from fortnight to fortnight, of course, taking care that the security in respect to the advance was lodged, and the responsibility of the broker with whom the Company dealt was guaranteed. They had lent £10,000 to the Edison Company, so that the £30,000 was mopped up. The National Telephone shares were now worth a good deal more than the present premium. They had got rid of £29,000 of Consols and £5,000 of Prussian Consols, the latter being sold at a profit and the others at about their value.

Mr. Cuthbert Quilter, M.P., seconded the motion.

The **Chairman**, in reply to questions, said that supposing the agreement were carried out, the whole of the £375,000 capital of the Swan Company would disappear, and the capital of the United Company would stand at £350,000 plus £100,000. On the expiration of the agreement with the French company, at the end of next year, the restriction as to selling lamps would be removed. He thought it was quite on the cards that the Company would see it to be to its interest to be free of that restriction, and to be able to compete all over Europe. The Edison and Swan Company was not free to export lamps from Great Britain. The lamp patents now were absolutely gone, and therefore it came to this, that they would have for £450,000 the business of all Europe for what it was worth, because, being together, the bar of exportation from England would be removed, and they would be able to make lamps for the whole world, China included. They had tried to turn out the most efficient article, and during the years of protection they had had a monopoly of all the scientific information. Their factory was the best in the world, and their operations had not been confined to lampmaking. The Directors knew quite well the quality of every lamp produced, because they had bought them and tested them. He had not yet discovered that lamps could be made more cheaply in Germany than in England. The Company

had been playing off its factory in Germany against its factory in London, and they found that the result in London was rather more satisfactory than it was in Germany, because it turned out quantity. The Company was allowed to sell Edison lamps and Swan lamps, but the Edison lamp had disappeared. All the refuse stock in Germany had been bought up by speculators, and would, no doubt, be launched here as first-class German goods. When it came to goods of a first-class character, the Swan Company would be able to compete with all comers. They had some extremely valuable patents, having some years yet unexpired, in respect of fittings which for the lamps were almost indispensable and were now being made by hundreds of thousands. The Company had licensed many of the best firms in England, from whom they obtained a royalty.

Mr. F. W. Reynolds enquired whether the capital would be cut down, and also as to the £1 10s. liability on the shares.

The **Chairman** said that, in round numbers, they would be £60,000 less on paper than before. He did not see that either company was in immediate fear of new capital being required, and he might say that the competition, up to the present moment, had not in any way affected their sales. The Chairman then explained at length a circular which had been issued to the fully paid shareholders as to the reason and consequences of the amalgamation.

The report was adopted, and the retiring directors, Mr W. Cuthbert Quilter, M.P., and Major Flood Page were re-elected, and a resolution was passed authorising the distribution of dividends as mentioned in the report.

ELMORE'S FRENCH PATENT COPPER COMPANY.

A meeting was held on Wednesday at the Holborn Restaurant of the debenture holders and secured creditors of Elmore's French Patent Copper Depositing Company, to consider a scheme of arrangement between the Company and its creditors. Mr. C. J. Stewart, the official receiver and provisional liquidator, presided. It was explained that the object of the scheme was first to satisfy the claims of the debenture holders and creditors of the Company; and, secondly, to resuscitate the Company, so that the reversion of assets might belong to the shareholders. The **Official Receiver** having stated that he presided under an order from the Court, said he wished to make it very clear that he did not recommend the scheme in any form whatsoever. If it were adopted, those present must distinctly understand that it was not a scheme recommended by the official receiver. He did not say that the scheme was not the best one that they could adopt, but at the same time they must judge for themselves as to whether they would adopt it. The scheme was adopted with one dissentient.

In the afternoon a meeting of the unsecured creditors was held. **Mr. Stewart**, the official receiver, who again presided, explained that the debenture holders had accepted the proposed scheme, and it now rested with those present whether they would accept it. Practically, the scheme put an end to the liquidation proceedings. He did not, as official receiver, wish to hold out any inducement to them that they would be benefited in any way by the scheme. The scheme having been read and explained, the **Official Receiver** said the creditors were best able to judge from their former dealings with the Elmore Company whether the new company was likely to be the success which had been foreshadowed. On the motion of **Mr John Heal**, seconded by **Mr. Shurmer**, it was decided to approve the scheme, subject to the sanction of the Court.

The shareholders of the Company subsequently held a meeting at the Holborn Restaurant, under the chairmanship of the **Official Receiver**, who repeated the observations made at the earlier meetings, to the effect that he made no recommendation one way or the other with regard to the scheme. In reply to questions, he said the Court might decline the scheme, and anybody might be heard before the Court in opposition to it. It was, however, doubtful whether the Court would vary the scheme at all without a fresh meeting. After some discussion the meeting approved the scheme subject to the sanction of the Court.

BUSINESS NOTES.

Ashover.—The hydropathic establishment propose to adopt electric lighting.

Western Union Telegraph Company.—A quarterly dividend of 1¼ per cent. has been declared.

Fermoy.—Tenders are invited by the Town Commissioners for lighting the town by electricity.

Aberystwith.—The Town Council have decided to erect an electric lift up Constitution hill.

Western and Brazilian Telegraph Company.—The receipts for the week ended December 15 were £3,215.

Cherry Hinton.—The question as to the best method of lighting the streets is under the consideration of the parishioners.

West India and Panama Telegraph Company.—The receipts for the two weeks ended December 15 were £182 more than for the corresponding period.

Calcutta.—Messrs. Kilburn and Co., of Calcutta, have taken up an agency for Messrs. Crompton and Co., and also for Henley's Telegraph Works Company.

Leeds.—Tenders are invited for fixing the various fittings requisite in electric lighting inside and out Wren's Hotel, New *Briggate.* Applications to be sent to Mr. J. Townsend, at that *address.*

Melbourne.—The complete lighting of the city of Melbourne by electricity is likely to be accomplished by the beginning of the new year at a cost of £70,000.

Halifax.—The proposal to erect the central depot for the electric lighting on the vacant plot on the east side of the Halifax Parish Church is said to be meeting with much opposition.

Burton-on-Trent.—New schoolrooms connected with George-street Free Methodist Chapel have been opened. The hall, which seats 600 persons, and the principal rooms are to be lighted by electricity.

Universal Electric Lighting Company, Limited.—This Company has been registered with a capital of £5,000, in 10s. shares, to carry on business as electricians, electrical and mechanical engineers, etc.

Norwich.—The Town Council have decided to light the Council chamber and committee-room and the municipal offices and sanitary offices by electricity. The annual expenditure will amount to £150.

Loan Granted.—Treasury sanction has been received by the London County Council for the following loan, which is awaiting completion: Hampstead Vestry, £5,000 for electric light buildings and works, 30 years.

Telephonic Communication.—The district manager of the National Telephone Company states that the question of making Cleckheaton a joint exchange between Dewsbury and Bradford will not be lost sight of.

Falmouth.—Mr Grose is the pioneer of electric lighting in Falmouth, having just completed an installation of arc lights in the windows of his three shops, the interior of which are illuminated by 50 c.p. incandescent lights.

Barnsley.—Tenders are invited for lighting the Barnsley arcade and adjoining property by electricity, for the Barnsley Arcade Company, Limited. Applications are to be addressed to Messrs. Wade and Turner, 10, Pitt street, Barnsley.

Bristol.—The Town Council last week adopted the recommendation of the Electrical Lighting Committee, that they be authorised to apply to the Local Government Board for their sanction to the borrowing of a further sum of £24,000 for lighting purposes.

Nelson.—The Town Council have adopted the minutes of the Gas Committee recommending the acceptance of the tender of Messrs. Siemens Bros. and Co., Limited, at £1,031, for coupled engine and dynamo. The engine is of the Willans HH type.

Stirling.—The Town Council are to receive a report from Mr. Arnot, electrical engineer to the Glasgow Corporation, for the guidance of the Council in connection with the application of the Caledonian Electric Supply Company for a provisional order.

Cardiff.—A meeting of the Lighting and Electrical Committee was held on Tuesday at the Town Hall. Tenders were accepted for 250 lamp columns, lamps, and lampholders respectively. It was decided to erect about 40 additional lamps in various parts of the town.

Edinburgh.—The Town Council of Edinburgh have remitted to the Cleansing and Lighting Committee the question of considering and reporting on extensions in the electric lighting of various streets. Estimates for the first portion of the work will be invited in about a week.

Aluminium Company.—Mr Justice Wright had before him on Wednesday a petition by the Company for the reduction of its capital from £400,000 to £80,000, by reason of loss of capital. His Lordship directed the petition to stand over for further evidence as to the loss of capital sustained.

Harrogate.—Tenders are invited, by the 30th inst., for the supply of concentric insulated cables for high pressure distribution for the Corporation of Harrogate. Specifications may be obtained of Mr. S. Stead, borough surveyor, Municipal Offices, Harrogate, on payment of £1 1s.

Capital Required.—A private electrical company wishes to increase its capital to meet the needs of its growing business. The company could employ from £1,500 to £3,000. Communications to be addressed to the company's solicitors, Messrs. Cave and Co., 4, Fenchurch street, E.C.

Pilling.—A complete electric lighting plant, comprising oil-engine, dynamo, accumulators, and about 50 incandescent lamps, is being laid down at Fluke Hall by Mr. E. Dewhurst, electrical engineer, of Blackpool and Preston. It is rumoured that the church is to be lighted by electricity.

City and South London Railway.—The receipts of the Company for the week ending December 17 were £905, against £918 for the same period last year, or a decrease of £13. The total receipts for the second half year of 1893 show an increase of £143 over those for the corresponding period of 1892.

Dewsbury.—The Lighting and Water Committee reported on the 9th ult. that nine tenders had been received for building the central electric light station, and that the tender of Mr. Mark Scott, of Earlsheaton, for lighting station had been accepted. These minutes have been adopted by the Council.

Personal.—Mr. B. Holmes Jenkinson informs us, now that he has completed the work of electric lighting the Southampton Docks, he has been appointed to take charge of Messrs. Crompton and Co.'s lighting contracts for the Great Eastern Railway Company at Liverpool street, Bishopsgate, Shoreditch, etc.

Kingswood.—At a meeting of the Local Board, Mr. H. Anstey enquired what Messrs. Parfitt had to say in relation to the inferior lighting of the district. The surveyor was understood to reply that the current was at fault. The chairman enquired when the iron

posts were to come. In reply, the surveyor said he believed they were at Warmley Station.

Agents.—Messrs. Henry Rogers, Sons, and Co., of London and Birmingham, have been appointed sole agents for the United Kingdom of the Fonderie et Tréfilerie de Bronze Phosphoreux d'Anderlecht (Montefiore Phosphor Bronze Works), manufacturers of phosphor copper, phosphor bronze, and phosphor wire.

Plant for Sale.—The Blackpool Corporation have for sale their recent arc light plant, consisting of 10 Siemens dynamos, 6,000 c.p. arc lamps, semi-portable Robey engine and boiler, 16 nominal horse-power, old cables, etc. Particulars as to terms may be obtained from Mr. Wm. Chew, Princess-street Works, Blackpool.

Lighting at Taunton.—The report of the Electric Lighting Committee adopted by the Town Council last week, stated that in consequence of the arrest of Mr. Hunt the committee had appointed the assistant engineer, Mr. W. Cousens, as engineer in charge *pro tem.*, and that they had made such other arrangements for carrying on the works as they considered necessary.

Eastern Telegraph Company, Limited.—The directors announce the payment on January 15 of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the preference shares for the quarter ending December 31, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, tax free, in respect of profits for the quarter ended September 30.

Huddersfield.—The Corporation invite, as will be seen from our advertisement columns, tenders for the wiring of and for the supply of electric light fittings for the model lodging house. Plans and specifications may be obtained upon application to Mr. A. B. Mountain, borough electrical engineer, St. Andrew's-road, Huddersfield. Sealed tenders to be sent to the borough electrical engineer not later than January 6.

Portsmouth.—Considerable progress is being made with the machinery for the supply of the electric light, and there is reason to expect that by the end of January the station will be complete. From a return just issued, the amount paid for purchase of land, erection of building, and other expenses up to October 16 last was £12,046, and the amount contracted, but not yet paid, is £36,650—in all £48,695. This will leave an available balance of £7,689 to provide for contingencies.

Yarmouth.—The Town Council have adopted a report of the Electric Lighting Committee. The committee stated the Mayor had been appointed chairman for the ensuing year; that the Board of Trade had approved the proposed method of lighting; and that the Local Government Board had sanctioned a loan of £15,000 for carrying out the scheme, and also approved of the site for the electric lighting station. Mr. Preece is to be instructed to prepare the specifications.

Liverpool Overhead Railway Company.—The directors have made a third call of £2 per share on 7,500 preference shares (first issue, Nos. 1 to 7,500 inclusive), payable at the Bank of Liverpool, Limited, Water-street, Liverpool, on Tuesday, January 9. The Board have also made a first call of £2 per share on 2,500 preference shares (second issue, Nos. 7,501 to 10,000 inclusive), payable on January 9. The traffic receipts of this railway for the week ending 17th inst. amounted to £634.

Bradford.—It has occurred to Mr. W. Glossop that, as the Bradford Corporation have succeeded in supplying electricity in the centre of the town in a most efficient manner, they might be induced to establish an installation in a district like Heaton if a sufficient number of the ratepayers could be found willing to use electricity in their houses instead of gas. For the purpose of testing the feeling of the Heaton ratepayers and obtaining information on the subject, he asks, in a circular issued to the ratepayers, that an accompanying form should be signed and returned to him.

Lighting at Wolverhampton.—As mentioned in our last issue, a report has been presented to the Town Council by the Lighting Committee with regard to the scheme for supplying the electric light. The committee were anxious that the installation of the electric light should be effected with the least possible delay, and among their recommendations was one that the tenders of the Electric Construction Company, Limited; Mr. John Thompson; the Epstein Electric Accumulator Company, Limited; and the Callender's Bitumen and Telegraph Works Company, Limited, should be accepted for the works included in the several specifications. The report, as stated last week, was adopted.

Monmouth.—At a meeting of the Town Council last week, Mr. Wilson referred to an article describing a system of electrical sanitation which was being experimentally tried at Havre. The Monmouth Corporation, he said, were in a specially suitable position for adopting such a system, if it could be proved effective, by the fact that they proposed working their sanitary and electric projects side by side. It seemed that they would be able in the course of time to put the sewage from the precipitation tanks right into the water at once. The point, therefore, suggested itself as to whether it was wise or not to saddle themselves with the cost of land which they would possibly not require at all.

Riggs v. Elmore's French Copper Depositing Company.—This was an action by the plaintiffs to have it declared that the sum subscribed for certain debentures was returnable in proportion to the amount of their subscription. The French Company proposed to issue £65,000 first mortgage debentures, and they issued circulars inviting shareholders to subscribe. It was stated that if the debentures were not fully subscribed the amounts would be returned to the subscribers. Only £2,000 or £3,000 was subscribed. That was paid into a bank. Under the circumstances the subscribers (of whom the plaintiff was one) applied for a return of their subscriptions. The Company went into liquidation, and the bank claimed to have a lien upon the sum in respect of overdraft. After some discussion, the defendants agreed to judgment, the money to be returned to the subscribers.

Luton.—A model electric light installation has just been finished at The Larches, Luton, the private residence of Mr. J. H. Green. The plant consists of a 3 h.p. nominal "Otto" gas engine, shunt-wound dynamo, and Epstein cells. The total number of incandescent lights is about 60, and the engine-house is about 50 yards from the main building, the lead-covered main conductors being conveyed underground across the lawn. The official trial of the plant took place last week in the presence of Mr. Albion T. Snell, the consulting engineer for the work. The London and Lancashire Electric and General Engineering Company, who have carried out this installation, have also been entrusted with the lighting of Lieut.-Colonel Martin's new residence, Petersham-terrace, Gloucester-road; Messrs. Wright, Layman, and Umney's premises, Southwark-street; and a special plant for organ blowing by electricity.

Lighting in Belgravia.—The Highways Committee of the London County Council reported on Tuesday last they had considered three notices from the Westminster Electric Supply Corporation of intention to lay mains (a) across Belgrave-road, (b) across and along York-street, south side, and across James-street, and (c) in Eccleston-street and place, Belgrave-square and place, Wilton-crescent, Halkin-street, Grosvenor-crescent and place, St. George's-place, and Piccadilly, from Apsley House to a point near Hamilton-place. The committee recommended that the sanction of the Council be given to the works referred to on condition that the company give two days' notice to the Council's engineer before commencing the work; that the details of the street boxes be submitted to and approved by him before the work is commenced; and that the covers thereof shall consist of iron frames filled in with materials to suit the paving.

Warminster.—The Local Board have discussed the question of an installation of the electric light for the lighting of the fountain in the Market-place, and the clerk has been authorised to sign an agreement with the railway company for the erection of a post on the company's premises for the carrying of the cable from Mr. Hill's premises to the fountain. The Chairman stated that he was prepared to carry a cable strong enough for a 2,000 c.p. light at his own cost. The question of the desirability of laying down a stronger cable in order to extend the light to two other points was then considered. The additional cost of having a stronger cable than that offered by Mr. Morgan was £16. It was generally felt that the stronger cable should be laid down, and that the question of extending the light to two other points should be left over for future consideration. Eventually it was decided to authorise the Lighting Committee to have the stronger cable laid down.

Factory Lighting.—The London and Lancashire Electric and General Engineering Company, Limited, have recently completed the overhaul of the main engines and machinery at the Bulbourne works of the Grand Junction Canal Company. Extensive alterations and additions to the plant have been made, including a complete system of electric lighting for the whole of the works, for which purpose it has been necessary to provide extra boiler power. To meet this want the company have put down a Davey Paxman boiler of the Lancashire type, 18ft. by 6ft. 6in., which besides supplying steam for the main engine, is of ample power to work a 6 h.p. nominal vertical slow-speed engine, belt coupled to one of the firm's new overtype shunt-wound dynamos, which can be utilised for accumulator charging purposes or supplying the lights direct. The wiring has been installed on the new water-tight system devised by Mr. C. N. Russell, the company's engineer, and as recently fitted by this firm at the Frogmore Mill, Hemel Hempstead.

Llandrindod Wells.—The clerk to the Local Board, at a meeting last week, read a number of communications as to electric lighting. He reported that a representative of the Severn Water Power Company, Shrewsbury, had made an inspection, with the view of utilising the River Ithon as motive power for generating electricity. The report of Messrs. Andrews and Preece, Limited, of Bradford, as to the installation of an electric lighting system was produced. A scheme for providing 2,000 8-c.p. lamps (which would yield a revenue of £1,000) would cost £4,000, and would entail an annual outlay, including repayment of capital, depreciation, wages, etc., of from £500 to £600. The price of the current was estimated at 9d. per Board of Trade unit, or equivalent to 4s. 6d. per 1,000 cubic feet of gas. The question of a generating station was not determined. The chairman and other members were in favour of having the whole question laid before and decided by a town's meeting. It was felt that the scheme was not yet sufficiently complete to do this. After full discussion, in the course of which a unanimous feeling was expressed in favour of the Board and not a company carrying out the work, it was resolved to defer the consideration of the subject pending the obtaining of further information.

Electric Communication Between Fire Stations.—The Fire Brigade Committee of the London County Council reported on Tuesday that early this year the Council authorised the provision of signalling apparatus at the 14 stations in the A district, in order to increase the facilities of communication between the superintendent and the stations under his charge, and to reduce the time occupied in sending on to fires assistance from stations adjacent to that at which the first call may be received. The system has now been in operation several months, and the chief officer states that it is of great advantage. The committee

accordingly proposed that it should be introduced at all other land stations of the brigade. The annual charge made by the Post Office for the apparatus in the A district was £81 15s. and it was estimated that the annual charge for the first seven years for the apparatus at the 44 stations in the B, C, D, and E districts would be £270. Against this, however had to be set a reduction of £80 in the annual charge for the telephonic apparatus at such stations. They recommended that subject to an estimate being submitted to the Council by the Finance Committee as required by the statute the offer of the Post Office to provide and maintain at the 44 stations in the B, C, D and E districts Stuart's signalling apparatus for £270 be accepted.

Lighting of Stafford. —As stated last week, an enquiry was held on the 13th inst. as to the application of the Town Council for sanction to borrow £20,000 for purposes of electric lighting. The Town Clerk, in stating the views of the majority of the Town Council with respect to the electric lighting application, said that the Council had called in Dr John Hopkinson to advise the gas manager upon a report which he had drawn up. Eventually, his report was presented to the Council, and had led up to this enquiry being held. The system to be adopted was the continuous current low tension method, with accumulators for light loads, and distribution by the three-wire system. Dr J Hopkinson who was called, stated that he had visited the site, and he considered it fairly convenient, and looked upon it as a great advantage that it was by the gasworks so that there could be some combination of the staff, and, in addition to that, a portion of the steam would be utilised for gasworks purposes. He had examined the plans of the buildings prepared by Mr Bell, after they had conferred together on the subject and they had his approval. The buildings would accommodate more machinery than it was proposed to purchase in the first instance, and would enable extensions to be made without further additions. He did not think they need spend more than £15,000 at the most to begin with, but would advise them to take powers to borrow £20,000. That would in no way interfere with the power of the Council to limit the expenditure.

Lighting of Bolton. —The ceremony of laying the memorial-stone of the new electricity works in Spa-road has just taken place. The ceremony was performed by Mr Alderman J Miles, J P, chairman of the Gas and Electric Lighting Committee. The town clerk Mr R G Hinnell) read a statement referring to the proceedings of the Council in the matter up to the present time. He said that the contracts for the plant had been placed with the following firms Steam engines and crane, Messrs. J and E Wood, £2,113 ; boilers, pipes, pumps, etc, Messrs. Hick, Hargreaves, and Co., Limited, £3,525 ; alternators and dynamos, the Brush Electrical Engineering Company, Limited, £2,257 ; high tension cables, Messrs. Siemens Bros and Co, Limited, £506 ; low tension cables, Messrs Siemens Bros and Co, Limited, £2,079 ; transformers the Brush Electrical Engineering Company, Limited, £550 ; switchboards, the Manchester Edison Swan Company Limited, Manchester, £930 ; accumulators, Messrs Crompton and Co, Limited £231 ; cast iron pipes, Staveley Iron Company Limited, £247 —£19,273. The works are expected to be completed and ready for supply of electricity early next year. The Mayor addressing the assembly, thanked the members of the committee for the devotion they had given, the time they had spent and the energy they had displayed in arriving at the best system, and obtaining all that would add to the success of the undertaking. The stone having been laid in position, Alderman Miles declared it to be well and truly laid.

London Electric Supply. —The Highways Committee of the London County Council reported on Tuesday that they had considered two notices from the London Electric Supply Corporation, of intention to lay distributing mains, etc in Dering street, Tenterden street, Harewood place, Princes street, George street, Fuller street, Maddox street, Mill street, and Brook street and also in another part of Mill street. The committee recommended that the sanction of the Council be given to the works referred to on the following conditions that the company give two days' notice to the Council's engineer before commencing the works; that the mains be laid under the footways and be kept 9in below the underside of the paving wherever it is found practicable to do so, that where the mains cross the carriageways they be kept at the same depth below the concrete or the road material as the case may be, that no pipes of larger size than 5in. shall be used, that no street boxes shall be constructed until the positions for, and the mode of construction of them shall have been submitted to and approved by the Council's engineer, that all pipes or openings from or into the boxes shall be of such shape as to remove all risk of injury to the covering of the cables; that all cables crossing the boxes shall be supported from below in the boxes, that all service lines or small cables shall be protected, where leaving the boxes, by an extra lead covering or by wooden stoppers, and shall also have a copper wire of sufficient size carried from the service to the main cable, in good connection with the lead or iron outer casing; and that the ends of all mains terminating elsewhere than in a box shall be securely protected by iron caps in addition to any other covering.

Cambridge. —The report of the Electric Lighting Committee of the Town Council with reference to the letter from the manager of the Cambridge Electric Supply Company Limited, dated November 2, which was considered at the last Council meeting, again came up for discussion last week. It was decided to refer the matter to the Lighting Committee for investigation. The Paving and Drainage Committee reported that they had considered the memorial from inhabitants of the borough asking that some provision might be made for the lighting of Parker's Piece, *and being of opinion* that the wishes of the memorialists would be met by the erection of a powerful light of 1,000 c.p. or 2,000 c.p. at the junction of the footpaths in the centre of the Piece, invited the gas company and the electric supply company to give them an estimate of the cost of the erection of such a lamp, together with the cost per hour when in use. In reply to the invitation of the committee, the gas company stated that they were at present unable to furnish an estimate for such a lamp. From the electric supply company the committee received an estimate, from which it appeared that the cost would be as follows: For erecting a lamp, complete £39 10s. ; for current per hour of a 10 ampere lamp nominally 2,000 candles, 2½d ; for carbons and attendance, per diem, 6d ; for cast iron pipes with two wires, 164 yards at 3s 9d per yard £30 15s. The company also intimated that they were prepared to supply the current for the first year free of cost, on condition that the Corporation would continue to pay for it after that time. The committee recommended that the estimate and offer of the company be accepted, and that they be directed to proceed with the work forthwith. The report was adopted.

The Blackpool Cars. —These cars are being temporarily worked by horses. A representative of a local paper has had an interview with Mr Councillor Pearson, chairman of the Electricity Committee. Mr Pearson said that the Council had been so erratic in their decisions that the committee had been placed in a very awkward position. In refusing to reappoint the electrical engineer as manager in charge of the tramway department, the committee were left without any responsible person to superintend the works. Yet they were bound to keep the trams going, and without authority from the Council they decided to employ horse traction. Mr. Pearson had full faith in the future of the Blackpool electric tramways. If they could obtain a perfect system the tramways could be made lucrative. The perfect system was that used at Budapest. He was in the South of France recently and took the opportunity of proceeding from there to inspect it. Through the medium of the consul he was introduced to the chief officials of the company which work this tramway, and he came away furnished with a mass of details respecting their system. They had 150 cars running regularly, over all sorts of points at all sorts of angles, and the system could have no higher recommendation than was bestowed upon it by Lord Kelvin, who remarked to Mr Pearson that it was the only perfect system of electric tramways which would be applicable to Blackpool. With regard to their present plant, the speaker observed that they had engaged Mr T. Parker, of Wolverhampton, to overhaul the whole of the line and electrical plant, and report to the committee. Then, with the Council's consent, they will ask Mr. Holroyd Smith the inventor of the system to overhaul it, for it was only due to him that he should have the chance. Mr Pearson's impression was that they will have to adopt a new system. In conclusion Mr Pearson said that it would be a couple of months before the report was furnished to the Council, and that in the meantime horse traction would be used.

Cork. —At a meeting last Friday of the Corporation, Mr Dwyer moved the suspension of the standing orders so as to allow the following recommendations of the Standing Committee to be dealt with "That the objections raised by the Board of Trade inspector to the scheme of the City Tramways Company, as approved by the Corporation, be answered as follows (1) That the Corporation is satisfied the branch tram through Marlborough street will be perfectly safe for the contemplated traffic; that unless this branch be sanctioned, tramway No 2 (to the Bandon and Passage Railway terminus) will be useless; and that the inhabitants of Marlborough street unanimously petitioned in favour of the tramway being laid through the street. (2) That the pressure of 500 volts as the potential of the electrical current be allowed in propelling the tramcars is set down as a maximum, that no regulations were stated to have been made on the subject by the Board of Trade, that a like maximum potential has been allowed in other towns, but the Corporation will assent to whatever potential may be decided upon within that maximum." The same committee on the 6th inst. included recommendation "That the order of Council of July, 1893, confirming recommendations of this committee in reference to the proposal to work the projected Cork tramways by electricity be amended, so that the Corporation shall sanction the working of same either by electricity or by horse power at the option of the promoters." Mr Rawe moved, and Alderman Hungerford seconded, the confirmation of the committee's recommendation, which was unanimously passed. Sir John Scott asked was there any possibility of the scheme being put into working order. Mr. J. W Bourke, solicitor, who attended on behalf of the company with reference to the matter, said certainly there was. They had been only waiting developments to know whether if they used electricity as a motive power they would get a return from the capital. They found that would be rather difficult, and they now proposed to make a tramway on a smaller capital which they hoped to have subscribed. A large portion had been already subscribed, and they would work the tramway by one horse cars.

Lighting at Weybridge. —The report presented to the Weybridge Electric Lighting Company by Mr A B W Kennedy, states that the present plant at Weybridge consists of two Thomson-Houston alternators, each having an output of 31 amperes at 1,100 volts, and each driven by a vertical compound steam engine made by Messrs. Bennett, Lindley, and Co., of Manchester, running at 240 revolutions per minute. The alternators run at about 1,500 revolutions per minute. Each alternator, if working at full power on an ordinary circuit, could keep about 900 8 c.p. lamps alight at the same time. The work done at the station is divided into two sections the private and the street lighting. For the former there is one main circuit each consumer having a

transformer on his own premises in the usual manner. For the street lighting there are three circuits. The public lighting is paid for by the local authority at the rate of £2 5s. per lamp per annum, which appeared to him to be a very low rate indeed. There are in all 119 lamps paid for in this way. Three other series lamps are separately paid for by individual consumers, and nine are used in the lighting of the station and the ground just outside it, making a total number of 131. As to the system adopted, Prof. Kennedy states that it is practically the only system by which at any reasonable cost the electric light can be introduced into a large and straggling district such as Weybridge. He concludes his report as follows: "I have no hesitation, therefore, in saying that if your demand for private lighting could be increased from the present number of 22 to about 75 or 80 consumers, assuming the average number of lamps installed by each one to remain as at present, the company would pay a small dividend on £16,000 besides putting aside a certain sum to reserve. The required increase in the number of consumers would not of course take place all at once, but if the matter were taken up locally, and pushed with vigour, I do not think that there ought to be much difficulty in obtaining the required increase. Of course the company might go on and pay its way, without making a profit, with a much smaller number of houses connected, but I believe that the number I have mentioned is about the smallest which would enable a reasonable dividend to be paid. On the other hand, after this number was once reached, any increase in the consumers would be accompanied by a very much larger proportionate increase in the profits." The lighting inspectors have accepted the offer of the Weybridge Electric Supply Company for renewal of lighting contract, subject to the wires being laid underground.

Lighting of Harrogate.—A scheme for the electric lighting of the borough, projected by Mr. George Wilkinson, M.I.E.E., consulting engineer, has been adopted by the Corporation. The scheme is intended, first, to produce and supply the electric light at a cheap rate so as to compete with the existing gas supply, which is in the hands of a company; and, secondly, to deal in an effectual way with the refuse collected from the ashpits of the borough. The results of exhaustive experiments made by Mr. Wilkinson on an extensive scale demonstrate, it is claimed, that town refuse, when put through a process of sorting, sifting, and drying, has a well-defined value as a fuel for generating steam power. The method hitherto adopted in many towns of placing the crude, wet, unsorted, material into immense brick kilns or furnaces, where it roasts for a time and smoulders, has not been found very suitable for generating steam. The capital cost of dust destructors is heavy, the combustion obtained owing to the presence of a large amount of moisture and incombustible matter is but feeble, and as a consequence the gases evolved are said to be deleterious to health. The system resorted to by Mr. Wilkinson is novel, and is a departure from all the methods of dust destruction hitherto adopted, and the correct term for this plant would appear to be the "refuse utiliser." The process in outline is as follows: The refuse is brought in carts or otherwise, and tipped upon a platform, whence it is automatically carried into a rough sifting apparatus which separates the old pots, cans, etc., the smaller material passing through the sifter and into a large hopper, from which it is forced in regular quantities into a drying cylinder, which extracts nearly one-third of its weight in the form of moisture. It then passes on to another sifter which takes out the fine dust, the resultant fuel being passed down a shoot and automatically injected into the special boiler furnaces. The dust is said to form a valuable manure, and the metal separated from the refuse is reduced to copperas by a simple process, whilst the rags are available for paper manufacture. Doubtless the outcome of Mr. Geo. Wilkinson's scheme at Harrogate will be awaited with general interest. The Town Council have decided to illuminate a certain defined area in the town by electricity according to Mr. Wilkinson's system. Mr. Wilkinson estimates that a complete installation for the supply of the area fixed upon could be put down for a sum not exceeding £12,000, and the annual earning capacity of this installation at 7d. per unit was £2,333, the estimated annual working expenses of the plant if worked continuously was £2,234, but if worked at night only the estimated profits were £500 per annum.

Lighting of Chelmsford.—A special meeting of the Town Council was held last week to consider the recommendations of the Lighting Committee with regard to the provisional order which is being sought by the Chelmsford Electric Lighting Company, and the requirements of the Board of Trade on the same. The first matter to give rise to discussion was the demand by the Board of Trade that the overhead wires should be placed underground; and while the committee recognised the advisability of adopting this order with regard to the principal thoroughfares, it did not consider the change necessary with regard to the less frequented roads. Mr. Chancellor reminded the meeting that in 1892 the company expressed its readiness to place the wires underground in the course of two years, and he was anxious to know why they were not now prepared to carry out their undertaking in full. Mr. Brittain explained that the committee had not deemed it necessary to put the company to the expense of placing all wires underground, and Mr. Tanner broadly hinted at the possibility that if the Council put the company to this very heavy expense, it might result in the withdrawal of the electric lighting of the town. Mr. Brown observed that he had gathered from enquiries he had made that to place the whole "electric system" underground would put the firm to an outlay of £23,000. The Lighting Committee, he said, were unanimous in their resolve not to put the company to any unnecessary expense. Mr. Bond directed attention to the value of the firm of Messrs. Crompton and Co. to the town, and he felt it would be nothing short of a calamity to Chelmsford were those works closed. A recommendation that the matter of the underground wires should be left to the judgment of the Board of Trade was accepted by a substantial majority of the Council. The offer from the electric lighting company to renew their contract for lighting the borough under arrangements as at present existing was next considered. Mr. Brittain moved, and Mr. Brown seconded, that the contract in question should be renewed. The resolution was adopted. On the matter of the provisional order for which Messrs. Crompton are now making application, and a draft of which was before the meeting, Mr. Chancellor opened the discussion with the declaration that no gentleman present understood the draft of the provisional order, and moved that the Council should employ an expert to advise them in the matter. The Town Clerk reminded the meeting that the provisional order was very similar to the license now held by Messrs. Crompton, and upon which they had already been advised. The only matters of real importance were the clauses dealing with the period that it should hold good, and the terms of purchase, should such at any time be deemed necessary. Mr. Duffield contended that the document deserved very careful consideration, and, in view of the lateness of the hour, the meeting should be adjourned. This course was adopted.

Walsall.—The General Purposes Committee of the Town Council reported last week that they had had before them a long report of the electric lighting scheme, proposed by the Electric Lighting Sub-Committee. They recommended that such report be adopted, and that the Council apply to the Board of Trade for approval of the adoption of a system of electric lighting for the borough on the principle suggested in such report—viz., high tension, with transformers; and also apply to the Local Government Board for their sanction to a loan of £19,650, in addition to the estimated value of the suggested site at the Wolverhampton-street gasworks, for the cost of carrying out the proposed scheme. The committee also recommended that the Council should enter into contracts with the Electric Construction Company, Limited, for the electrical plant for the sum of £10,003; with Messrs. Bumsted and Chandler for the engines, for the sum of £1,350; and with Messrs. H. and T. Danks for the boilers for the sum of £805, as soon as the approval of the Board of Trade and the sanction of the Local Government Board is received; and, further, that the Electric Lighting Sub-Committee be empowered to do all things necessary for carrying out the works mentioned or referred to in the above-mentioned report. The Town Council adopted the report. At the same meeting the Streets Committee reported that they had received from their electrician, Mr. Frederick Brown, a letter respecting the electric trams. Mr. Brown stated that he had kept a constant supervision over the running of these trams during the last 11 months, and that the running on the whole has been very satisfactory. Continuing, Mr. Brown says: "There have been a few cases where the cars have been hauled in through slight accidents in the mechanism, and three times the trolley wire has been down in that period, but no damage has been done to either person or property. There has also been some little trouble with the insulation of the feeders. Messrs. Callenders have been down and replaced one length along the bottom of Bradford street, near the Midland yard. The fault here was caused by wet getting into the joint box at the foot of the pole, and the water travelling along the strands of the cable caused a fault some yards along; this piece has, however, been taken out. The fuse box at the corner of Blue lane has also given considerable trouble; a new pattern has been designed and put in, making the connections much more secure, and giving much greater freedom for testing than the old one. I think now there will be little, if any, further trouble in this respect. I have communicated with Mr. Dickinson many times, and particularly about the safety of the wire where it is attached to the insulators. These points he has recently overhauled throughout the length of the line, and he assures me that they are in better condition for standing the winter storms than they were when first put up. As you are aware, the number of passengers has increased very considerably, the number being 2,245,660 in 1893, against 1,871,816 in 1892. So far as I can gather from the public expression of opinion, everyone seems well satisfied with the change from steam to electricity, and the 'unsightliness' of the wire appears to be completely forgotten or overlooked. I may here again call your attention to the fact that I have several times had the whole of the current through me, so that I have no hesitation in saying that there is not the least cause for apprehension with regard to the severity of the shock to any human being. I mention this particularly so that firemen or policemen may have confidence in cutting down a wire if it should be necessary. It is possible that, should the wire be accidentally broken and fall upon a horse, the shock would be sufficient to knock him down; this is the only fear I have for the future. If the tramway company can keep a pretty good supervision over the line, the trouble from this cause will be reduced to a minimum." This report was adopted. The Town Council granted permission to the South Staffordshire Tramways Company to fix feeder boxes under the footpaths in the borough.

Lighting of Fleetwood.—The Highway and Lighting Committee of the Town Improvement Commissioners on the 29th ult., recommended that the following tenders for electric lighting be received: Messrs. Parsons and Co., Messrs. Siemens Bros. and Co., Messrs. Greenwood and Batley, Messrs. Andrews and Preece, and the Brush Electrical Engineering Company. On the 5th inst. the same committee again considered the tenders and correspondence, and Mr. Dawbarn, from the Brush Electrical Company, Limited, attended for interview with the committee. It was then recommended that the report to the Board from this

committee upon the proposed installation of electric lighting in this district should be drawn up by the chairman of this committee and the clerk, and that the report, including the recommendation of a tender for the same (excluding buildings) should be laid before the Board at the next meeting. Last week the Improvement Commissioners had before them the report in question. The report stated that the committee, after investigation, coupled with the results of inspection of various electric lighting stations, were now in a position to offer recommendations. The chief object had been to secure for the town the best system, consistent with (a) moderate capital expenditure, (b) economical working expenses, (c) reliability and safety. It was the opinion of the committee that the superintendence of the requisite work should be placed in the hands of a competent resident working electrical engineer, and that such engineer should have charge of the works during construction, and afterwards take entire control of the department. Since the order was obtained over 16 complete schemes had been submitted to the committee. The original tenders were based upon the use of steam power, but ultimately the committee invited tenders, coupled with the information as to successful installations which had been obtained. Information was supplied to six selected firms, and complete tenders were invited concerning the building and site for station. The buildings and foundations for the machinery were recommended to be erected in the town's yard, London-street, and this portion of the work should be let by tender to local builders. The motive power recommended was to be provided by means of producer gas plant, working suitable gas-engines. The system recommended to be adopted is the high tension alternating system. With regard to public street lighting, provision was made for all the present street lamps to be lighted by electricity, ordinary streets to have 16 c.p. lamps, and the esplanade 32 c.p. Two large arc lamps were to be provided. The lamps numbered 232, and the committee reported the proposals contained in the tender they had decided to recommend were entirely satisfactory. Tenders were received as under: Messrs. C. A. Parsons and Co., Newcastle; Messrs. Siemens Bros. and Co., London; Messrs. Greenwood and Batley, Leeds; Messrs. Andrews and Preece, Bradford; and the Brush Electrical Engineering Company, London. The recommendations of the committee to the Board were: (1) That the tender of the Brush Electrical Engineering Company be accepted. (2) That, subject to consent being obtained, the requisite instructions be given for the preparation of the plans, sections, specifications, etc., required for the electric lighting station and gas tank in the town's yard, together with the construction of transformer chambers in streets. (3) That the committee be empowered to invite applications for the appointment of a resident working electrical engineer and to report to the Board upon the applications. In conclusion, the report stated the total capital required for the complete installation would not exceed £11,000, and it was believed the scheme would prove not only self-supporting, but in a short space of time would be working at a profit. The question of fitting up consumers' premises by the Board's workmen had not escaped attention, and the proposals of the committee upon the question of payment for the electric current and payment of the fittings by instalments, would be reported at an early date. The report is being printed, and copies are being supplied to the members with the clerk's analysis of the tenders. The report is to be considered at a special meeting of the Board.

PROVISIONAL PATENTS, 1893.

DECEMBER 12.

23857. **Apparatus for generating electricity.** David Cook, 30 Lancaster park, Richmond, Surrey.

23862. **Improved means for the automatic regulation of the position of the brushes of dynamo-electric machines and electromotors.** Ernest Hamilton South, St. Helens, Westwood park, Forest Hill, London.

23881. **Improved method of and apparatus for heating metals electrically.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

23883. **Improvements in relays for use with alternating currents also applicable to vibrators.** Hermann Aron, 6, Lord-street, Liverpool.

23897. **Improvements relating to electric signalling or the transmission of information and energy by electricity and to apparatus therefor.** Charles John Reed, 45, Southampton buildings, Chancery-lane, London. (Complete specification.)

23902. **Improvements in and relating to electric motors.** William Phillip Hall, 45, Southampton-buildings, Chancery lane, London. (Complete specification.)

23913. **Improved process and apparatus for dissociating soluble salts by electrolysis.** Reginald Haddan, 18, Buckingham street, Strand, London. (Henry Spencer Blackmore, United States.) (Complete specification.)

23914. **Improvements relating to the insulation of submarine and other electric cables.** Jules Auguste Bisson, 18, Buckingham-street, Strand.

DECEMBER 13.

23951. **Telegraphic apparatus.** Thomas Bassnett, 15, Water-street, Liverpool.

23962. **An electric fire-escape.** Alfred Charles Hewitt and George William Pyke, 56, High-street, Maidenhead.

24001. **An automatic thermo-electric lubricating apparatus.** John Coombes, 8, Quality court, Chancery lane, London. (Rupert Napier Coombes, Western Australia.)

24017. **Improvements in or relating to processes and apparatus for obtaining and depositing metals by electrolysis, and in the treatment of the metals after leaving the electrolytic bath.** Ernest Stouls, 55, Chancery-lane, London.

DECEMBER 14.

24035. **A combined regulating switch, and motor for actuating same.** George Combe and Siemens Bros. and Co., Limited, Penny Bank chambers, Halifax.

24055. **A means of governing or controlling automatically the electric current generated by a dynamo or electric generating machine.** John Henry Cooper, 25, Roches street, Limerick.

24081. **Improvements in the manufacture of carbon for electric lighting and other electric purposes.** Regin Niewerth, 37, Cursitor street, Chancery lane, London.

24104. **Improved combined tidal motor dynamo-electric generator and storage batteries.** Robert Dunbar Radcliffe, 45, Southampton buildings, Chancery lane, London.

DECEMBER 15.

24131. **Improvements in or appertaining to the electro-deposition of zinc.** Matthew Andrew Mosley, Robert Wright, and John Henry Richardson, 20, Charles street, Bradford.

24154. **Improvements in electrical guides or indicators and batteries therefor, specially applicable for carriages and the like.** Ronald Leighton Grahame and Edward Smelter Cadman, The Limes, Teddington.

DECEMBER 16.

24217. **Improvements in electrical measuring instruments, and apparatus for use with alternating currents.** William Edward Ayrton and Thomas Mather, Central Institution, Exhibition road, London.

23234. **Improvements in the manufacture of filaments for incandescent lamps.** Alfred Charles Cossor, 21, Finsbury pavement, London.

24241. **Improvements in primary batteries.** Henry Weymersch and Edwin Freund, 40, Great Smith-street, Westminster.

24243. **An improvement in electrical arc lamps.** W. H. Lander, 33, Blessington-street, Dublin.

24271. **Improvements in and connected with telephonic apparatus.** Clement Bonnard and François A. Piat, 4, South street, Finsbury, London. (Complete specification.)

24274. **Improvements in apparatus for the electrolytic decomposition of metallic salts.** Carl Kellner, 46, Lincoln's inn fields, London.

24276. **Improvements in apparatus for electrolytic purposes.** Herbert Guthrie, 46, Lincoln's inn fields, London.

24285. **Improvements in means for connecting or supporting electroliers, brackets for electric lamps, or the like to or from ceilings, walls, or other places of support.** Henry Edmunds, 47, Lincoln's inn-fields, London.

SPECIFICATIONS PUBLISHED.

1893.

757. **Electrodes.** Barnett.

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3488. **Telephones.** Forbes.

15519. **Electric engines.** Barker. (Lawrence Electric Company.)

18482. **Determining the presence and intensity of atmospheric electricity.** Opperman.

19789. **Electric railways.** Pitt. (Universal Electric Company.)

20069. **Controlling electric currents.** Lundell and Johnson.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¼
— Pref.	—	2⅜
Charing Cross and Strand	—	5
City of London	—	11¼
— Pref.	—	13
Electric Construction	—	1¼
House to House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22¼
Liverpool Electric Supply	5	5¼
	3½	4⅜
London Electric Supply	5	1
Metropolitan Electric Supply	—	8
National Telephone	5	4⅞
St. James', Pref.	—	8½
Swan United	3½	3¼
Westminster Electric	—	5¼

NOTES.

The Poor Man's Light.—Foreign-made matches.

"Those Electric Belles."—The ladies of the ballet.

Many of Them.—A happy and prosperous New Year to all.

He Receives a Shock.—The reader of an electrical contemporary when he finds stale news in it every week.

Sparks from the Anvil.—An inventor has not applied for a patent for obtaining electricity from a cat's tail.

Those Falls Again.—A Swiss electrical engineer states that there is no connection between the Falls of the Rhine and the Falls of Niagara.

The Brush Diary.—We have received from the Brush Electrical Engineering Company, Limited, a handy diary for 1894 for the vest pocket.

South London Railway.—The City and South London Railway Company report that the traffic during the holidays was about the same as last year.

He Saw Stars.—But it was only his friend Brown who had placed the knocker in an electrical circuit in conjunction with a metal plate laid on the steps.

Telephony between St. Martin's and New York. The attempt made yesterday to telephone from St. Martin's-le-Grand to New York was unsuccessful.

Across the Channel.—A Parisian friend writes to say that it is incorrect that a French syndicate intend to construct an electric railway between Calais and Dover.

Not any Longer.—We understand that an electrical contemporary is not to be published any longer. This is gratifying news. The paper is already long enough.

The Engineering Laboratory at Cambridge.—Prof. J. A. Ewing in the *Times* of Wednesday makes an appeal for funds in aid of the engineering laboratory at Cambridge.

Spanish Nuts.—A Spanish correspondent contradicts the rumour that most of the electrical work in Spain is being carried out by French firms. He says that the Teutons are doing it.

Diamonds.—Some people are experimenting in the direction of making diamonds by electricity; others are producing electricity from diamonds, but these are, of course, "black diamonds."

The Torpedo Did not Arrive.—Our German correspondent informs us that there is no foundation for the statement that an electric torpedo is to be despatched from Kiel to the mouth of the Thames.

Proposed Exhibition.—It is stated that the idea of holding an industrial exhibition at Cardiff, and which originated with Mr. Ross, electrical engineer at Cardiff docks, is likely to assume practical form.

Thousands of Volts.—An American professor is reported to have taken thousands of volts. This is quite insignificant; many people, according to the sporting papers, have taken hundreds of thousands of vaults in this country.

Mechanical Traction on Tramways.—In view of the proposed adoption of cable haulage of tramcars in Newcastle, a local paper has this week published two articles on this subject—comparisons being made of steam, horse, cable, and electric systems.

The E.P.S. Blotting-Calendar.—The Electrical Power Storage Company, Limited, have forwarded us one of their combined desk blotting-pads and diaries for 1894, and giving particulars of the E.P.S. batteries for lighting and traction purposes.

Cost of City Lighting.—The accounts of the Commission of Sewers are very interesting as a financial record. The consolidated account contains the following item: Lighting, £22,477 (which shows a considerable increase on account of the electric lighting).

He Didn't Mind 1,000 Volts.—"You don't mind getting 1,000 volts," remarked a central-station engineer to a friend to whom he was showing the back of the main switchboard in the station. "No, not at all," was the reply; but I prefer to receive it at my house transformer—stepped down."

Clarke's Tables.—We have received a new and enlarged edition of this pocket-book, published by Messrs. Bush and Co., 93, Fleet-street. These tables are not directed mainly to electricians, but to plumbers, though a new section devoted to electrical matters has been added. The tables are such as appeal to practical men.

Water Power in Switzerland.—It is announced that the question of monopolising by the State of all the Swiss water powers will be seriously proposed in the spring session of the Swiss Federal Council. The Federal Council commissioned Mr. A. Jegher to make an inspection of all the water forces in the country, and to draw up a report for use at the forthcoming discussion of the proposed law.

Cable Communication.—The Hon. Mackenzie Bowell, Canadian Minister of Commerce, in an address delivered recently before the Honolulu Chamber of Commerce, referred to the necessity of cable communication between Canada, Hawaii, and Australia. He announced the conference which is to be held on the subject in Canada next year, and invited Hawaii to send a representative.

Small Industries at Niagara.—The Cataract Construction Company anticipate that there will arise at Niagara a number of small businesses in the machine line which cannot afford to erect a shop. To accommodate these the company propose to erect a large building, furnish it with shafting, divide it off into rooms, provide it with power, and lease floor room as may be desired. The power will be electric.

The "Medical Battery" Company, Limited.—At Marlborough-street police court on Wednesday, Mr. Hannay resumed the hearing of the charges of conspiracy to defraud brought against Mr. Cornelius Bennett Harness, the managing director of the Medical Battery Company, Limited; Mr. James Montgomery M'Cully, a physician; and Mr. Charles Beavington Hollier, a salesman. The proceedings were again adjourned.

Traction at Dudley.—The Dudley and Wolverhampton Tramway Company are about to apply to the Board of Trade for sanction to construct a tramway from the Dudley-road to Bilston. This line will probably connect with the Dudley and Wolverhampton service, and the terminus at Bilston will be outside the Town Hall. It is suggested that it would be a decided improvement if the tramway company would adopt electricity in preference to steam power, as at Walsall.

Gas Explosion at Glasgow.—On Tuesday an explosion of gas occurred at a manhole in Renfield-street in connection with the system of lighting the streets by electricity. Fortunately, no one was hurt; but as many of the footpaths are underlaid by cast-iron troughs containing the cables, and as accumulations of gas are frequently occurring in the troughs, the accident caused

much excitement. This is the third explosion of the kind that has taken place within a short time.

Storage Battery Traction. — Experiments are being made at Oneida, N.Y., with a street car propelled by a motor energised from storage batteries made by the Syracuse Storage Battery Company. The total run on one charge of the batteries is stated to have been 125 miles. The car makes daily from 64 to 90 miles without a break in the service. The 125-mile run was made on a seven-hour charge. There are 96 cells used in the car. The motor is a single 30-h.p. Rae type.

Train-Lighting.—The penny-in-the-slot apparatus is now in full operation in the carriages of the District Railway, but a daily paper submits that the lighting cannot be considered satisfactory. The intention was that the light should only fall on the book or newspaper of the person who dropped in the penny; but the apparatus is said to be so placed that when the compartment is full the light neither benefits the person sitting next the window nor his next neighbour, but falls between the two.

Scenic Effects.—The electric light plays a fairly prominent part in the scenic effects of "Robinson Crusoe," at Drury-lane Theatre. Portable batteries are used for, among other purposes, illuminating shells carried in the ballet and for head decoration. At the Lyceum, where "Cinderella" is being produced, electricity also occupies a fair position. The electric light is used with great effect in the ballroom scene, the garden background being lit with tiny electric lamps, while the slipper dropped by "Cinderella" in her flight flashes with electric light.

Oxford Local Exams.—The thirty-sixth annual report of the delegacy has just been issued by the secretary to the delegacy, Mr. H. T. Gerrans, M.A., Worcester College. It states that in electricity and magnetism the knowledge shown was poor. The definitions of magnetic lines were very loose and inexact; the explanations of the action of an ordinary electric machine omitted all reference to induction, and the function of the points on the prime conductor, the properties of solenoids—indeed, solenoids themselves seemed unknown.

Junior Engineering Society.—At the last meeting of this society, Mr. Percy Waldram in the chair, a paper was read by Mr. S. Cutler, jun., on "Coal-Gas Manufacture, and Recent Improvements of the Plant Employed therein." In conclusion, the cost of manufacture, by-products, the future of gas considered in respect to electricity, and gas employed as a heating agent were touched upon. The next meeting of the society will take place on January 5th, at the Westminster Palace Hotel, when a lecture on "Boiler Incrustations and Deposits," by Prof. Vivian B. Lewes, will be delivered.

Obituary.—The death of Sir George Elliot removes another of the band who were connected with the laying of the Atlantic cable. In July, 1892, Mr. Cyrus Field died; Sir J. Anderson, and now Sir George Elliot have followed. In the expedition of 1857 one half the cable was supplied by Glass, Elliot, and Co.—since then converted into the Telegraph Construction and Maintenance Company—the other half by Newall and Co., so that the cable was supplied by two firms whose principal partners were Tyneside men. Sir George Eliot retained to the last his interest in submarine telegraphy.

Electric Mail Cars.—Two electric postal cars, to be run in connection with the street-railway service, for carrying the mails between the post office and the several railway stations, have just been built at Ottawa. The Postmaster-General entered into a contract with the street-railway company to try the experiment, with a view to the system being introduced in other cities in Canada where the street-railway service was operated by electricity. The cars are equipped with 30-h.p. motors, and the result has been satisfactory. The postal authorities estimate that where it took 20 minutes to convey mails from the post office to the railway station by the old system, the same service can be performed now in five minutes.

American Wiremen to be Licensed.—The New York Board of Underwriters have authorised the president of the board to address a communication to the Governor of the State of New York calling his attention to the enormous increase in late years of damage by fire, due largely, in the opinion of the underwriters, to the improper wiring of buildings for electric light or power, and asking his influence to secure legislation which shall require that no person shall be permitted to wire buildings for electric light or power purposes who has not been duly licensed as competent to perform the task by some board of control competent to test the qualifications of applicants for licenses, as is now the case in connection with engineers having charge of boilers, etc.

They Dined in the Chimney.—The Brooklyn City Railway Company are introducing the trolley system on a large scale. The chimney at the power-house is said by the engineers to be the largest chimney yet built in cubic capacity, the inner core, or chimney proper, having 65,800 cubic feet of air space. The stack is 293ft. high, the sides of the base measure 38ft. 3in., and taper in to a height of 85ft. where the circular form is assumed. The iron cap surmounting this big stack weighs about five tons, and is 27ft. in diameter. The chimney is designed to carry away the smoke and gases from 36 250-h.p. boilers using forced draught. The new power-house was designed by Mr. F. S. Pearson, of Boston. To celebrate the completion of the chimney, a dinner, to which about 60 guests were invited, has been given in its interior.

Electric Light and Architecture.—Mrs. Meynell, in an article in the *Pall Mall Gazette*, on "The Light—That Queen of Colours," states that the bad old fashion of lighting from above is reappearing with the general use of electric light. That most beautiful illumination would leave nothing to be desired were it always placed with care. As for its shading, it must be hoped that this is not often omitted, as one has unfortunately seen it, in nurseries. When gas is done with, we shall be rid of an illuminant that never went well with architecture or with natural things. The electric light goes as well with them as moonlight. In the old Grand' Place at Brussels the high masts, carrying a ball of the blue-white electric light high in the air, give an entirely appropriate beauty to the faces of the ancient Flemish Gothic houses. Electric light would look in place in a deep-sea cave if it could be got there.

Telephony at the Antipodes.—So rapidly is science extending its conquests (says a Melbourne paper) that many sheep stations which were formerly only connected by the dreary tramp of the sundowner are now linked together by the telephone. So long as a squatter keeps his telephone on his own property he is quite within his rights, but if his wires cross a public road he renders himself amenable to the law, which forbids a private person to erect a telephone or telegraph, the monopoly being reserved for the Government. The Postmaster-General does not wish to prohibit telephones under such circumstances, and he has therefore had regulations prepared, which have been passed by the Governor in Council, charging a license fee of £1 per mile per annum for the first four miles, and after that 10s. per mile; the fee, however,

in no case to exceed £7 per annum. The height at which the wire must be carried across roads is specified, and it is also provided that in no case shall a fee be charged or accepted for the use of the line.

Railway Station Lighting.—The railway terminus at Liverpool-street will, when the addition is completed, cover no fewer than 15 acres of land. The arrangements for the electric lighting of Liverpool-street are on a large scale. Facing High-street, Shoreditch, is the building which contains the generating plant, which will brilliantly illuminate nearly 15 acres. This erection is surmounted by a shaft 150ft. high. It contains three 35 nominal horse-power compound engines by Davey, Paxman, and Co., with Crompton dynamos, and other engines will, it is expected, soon be added. Liverpool-street and the goods and passenger stations at Bishopsgate-street Stations will be lighted from the same building. Accumulators will be used as regulators. The station will be lighted by means of arc lamps, while the offices and hotel will be illuminated by incandescent lamps. In no greater degree has gas been so thoroughly superseded, and in addition to this it is proposed to apply the electric current for the transmission of power to cranes, ventilating-fans, etc.

A Large Electric Railway Project.—It is stated that Mr. Foster, ex-Secretary of the Treasury, is at the head of a syndicate to build an elevated electric railway between New York and Chicago, and they announce that, although the cost is expected to reach £20,000,000, they have already succeeded in interesting enough capital to ensure the consummation of their plans. The plans of the company propose a double track line to be built entirely of steel. By the elevation of the tracks there will be no grade crossings or other obstructions to a high rate of speed, and it is expected that the new line will be able to afford a passenger-train schedule of over 100 miles per hour. The syndicate have already secured patents for devices to prevent the cars leaving the tracks, and there can be no collisions, as no switches will be permitted on the road, the intention being to use it for passenger and mail traffic only. The present plans of the company contemplate a route that will embrace New York, Philadelphia, Pittsburgh, Cleveland, Sandusky, Toledo, and through to Chicago. It is expected that the run from Chicago to New York will be made in 10 hours.

Lighting Street Gas-Lamps by Electricity.—An electrical system of gas-lighting for city streets which operates devices located miles from a central station, without any electrical connection between them, is reported to have been introduced by the Cutler-Hammer Manufacturing Company, of Chicago, Illinois. This system discards overhead wires and the underground circuit, and adopts a new method. Each lamp is supplied with two sal-ammoniac batteries and a spark coil placed in an iron box buried in the ground at the foot of the post. In the lantern is a miniature gasholder of about two cubic inches capacity, pivoted on a hinge and held down by weights, and directly over this holder is an automatic gas-lighter, similar to those used in houses. Two wires about 10ft. long connect the lighter with the batteries through the post. Such an installation is under control from the gasworks. When it is desired to light the lamps of a city, it is only necessary to open the valve connecting one of the large gasholders at the works direct with the gas-mains. This results in a decided increase of pressure in the gas all over the city, sufficient to cause all the little gasholders in the lampposts to lift up about one-eighth of an inch against a platinum stop, and thus close the local battery circuit at each post. The automatic lighter being then supplied with current, immediately turns on and lights the gas.

Electric Lighting of Ships' Magazines.—Since the adoption of the electric light on men-of-war inconvenience is said to have often been caused through the sudden failure of the dynamo or some other portion of the electrical circuit, and which has put a ship in temporary darkness. The Admiralty, having recognised that the sudden failure of the electric light in the magazines and shellrooms might lead to confusion and become a source of danger in action unless some alternative means of illumination were provided, have issued instructions that in all ships in which the magazines or shellrooms are electrically lighted the lighting is to be so arranged that the electric lights and candles can be used at the same time and separately. Experiments have been carried out in the "Hood," "Grafton," and "Thetis," and no difficulty in these ships has been found in keeping candles burning in the present pattern light-boxes, provided the watertight doors of these boxes are left slightly open and the perforated doors are closed. In ships where difficulty is experienced a special kind of lamp, as used in coal-bunkers, will be provided. It has been decided to supply for use in the more important magazines and shellrooms a portable electric hand-lamp, about which further instructions will be given after experimental trials have been made.

Electrical Conductivity of Flames and Gases.—Mr. A. de Hemptinne deals with this subject in the *Zeit. Physikal Chem.* He so connected two platinum electrodes, one with a galvanic element and the other with a capillary electrometer, that the presence of a conducting substance between them was indicated by the mercury in the electrometer assuming a negative charge and moving upwards in the capillary. No effect was noticed when the electrodes were immersed in nitric oxide and oxygen gases in the act of combining, even when the E.M.F. employed was 100 volts. The same negative result was obtained when the reacting pairs of gases were hydrogen bromide and chlorine, and hydrogen chloride and ammonia. The influence of temperature was noted by placing the electrodes at the same relative part of a Bunsen flame, the combustible gas containing variable quantities of an indifferent gas. The hydrogen flame and the carbonic oxide flame conduct well, the conductivity increasing with rise of temperature. Observations were also made on the conductivity of explosive mixtures at the moment of explosion. There is decided conductivity in the case of oxygen-hydrogen and chlorine-hydrogen explosions, and a much slighter amount in the case of oxygen-carbonic oxide. Although hydrogen chloride and ammonia show no conductivity by themselves at moderate temperatures, dissociating ammonium chloride conducts fairly well. Ammonium bromide behaves similarly, but vapour of amylene bromide, although it is dissociated, does not conduct. Nitric oxide is a non-conductor.

An Imposing Catalogue.—The seventh edition of the catalogue of electrical supplies and wiremen's sundries just issued under the title of "Electricity" by the General Electric Company, Limited, forms a handsome volume of nearly 500 pages, containing numerous illustrations throughout. This edition has been rendered necessary by the many inventions and improvements introduced in the company's manufactures during the past two years, and the present catalogue deals with all kinds of supplies required by contractors for the interior wiring of houses. On turning over the first pages one finds descriptions and illustrations of switchboards for practically all purposes. Next come switches, and of these there is a very large variety. The company divide them into two classes—namely, main switches and branch switches: the former are for 20 amperes and upwards, and the latter

circuits of smaller capacity. These switches are again divided into single pole and double-pole switches. Following these is an extensive collection of wall plugs, ceiling roses, combination sliding pendants, cut-outs, and lampholders. We next find the "Robertson" incandescent lamp, which is now being made in two types—viz., those of long life and those termed economic, and of candle-powers ranging from 8 c.p. to 50 c.p. Passing on from lamp sockets, the catalogue then considers ammeters, voltmeters, and testing instruments, Byng arc lamps, projectors, and resistances; and plans, hints, and estimates for wiring houses are given. The volume next deals with the concentric system of wiring, insulators, tools, dynamos for different purposes, secondary batteries, boilers, turbines, fixtures, etc. The concluding parts of the catalogue, which will prove of great value to contractors, deal with electric cooking apparatus, bells, telephones, medical apparatus, etc.

A Large Water-Power Scheme.—Some time ago Mr. Thomas Oddy, electrical engineer, of Rochdale, received instructions to prepare specifications and estimates for the utilisation of waste water power for electric lighting and power purposes in Southern India. The project was to transmit 12,000 h.p. from some extensive waterfalls to two large towns some distance away. The towns in question are so far apart and away from the falls that it will necessitate a cross-country power transmission line (poles and conductors) being laid, 110 miles in length. Some idea of the magnitude of the scheme will be understood by the following abstract from Mr. Oddy's report: 3,000,000 cubic feet of water per minute is precipitated over the falls, with a clear drop of 200ft.; 12 1,000-h.p. turbines will be required, 12 towers, 10 bridges, 144 alternators, motors, and dynamos, of an average capacity of 250 h.p. each; telephonic communication from end to end and at five intermediate stations; 3,300 poles; 24,000 miles of wire made into cables; two large central-station buildings, two transformer stations; 96 transformers of 250 h.p. each; massive switchboards, weirs, flumes, sluices, etc. The whole scheme when completed will cost £350,000. After making allowance for interest on this loan, paying £10,000 as a yearly instalment to decrease loan, paying working expenses, inclusive of cost of maintenance, and depreciation of plant, machinery, and buildings, a profit of £7,000 per annum is anticipated. The current will be utilised for power and lighting purposes in cotton mills, corn and rice mills, for domestic purposes, in machine shops, for pumping, working cranes, hoists, mineral-mining and coal-cutting, haulage of canal tug-boats, tramways, and various other purposes. Mr. Oddy is now also engaged on a similar scheme for some public authorities in Southern Russia. This project is for transmission of 5,000 h.p. a distance of 93 miles.

Electricity in Mining.—As mentioned in our last issue, a paper has been read by Mr. R. H. Wynne before the North Staffordshire Institute of Mining and Mechanical Engineers at Stoke-upon-Trent on "The Application of Mechanical Arrangements in Underground Operations." He said that the subject might be classified, as far as regarded motive power, in the following divisions: (1) Horse power, (2) steam, (3) compressed air, (4) electricity, (5) combustion of petroleum. Electricity as a medium for the transmission of power had not by any means attained its fullest development, but during the past four or five years its use for colliery purposes had received an immense impetus, and there was no doubt, the author remarked, that it would become in a short time the medium *par excellence* for the transmission of power over long distances underground for a variety of purposes—*e.g.*, hauling at far-away stations where the main haulage worked from the surface or engine at the bottom of the shaft was not conveniently applicable, pumping water from the bottom of inclines under similar circumstances, and actuating drilling and coal-cutting machines. It also afforded the means of obtaining superior lighting on the surface and in the main roads underground, and most likely in the near future a portable and safe light for the working collier. The advantages of an electric system for districts not easily accessible to direct steam-power or compressed air motor might be summarised thus: a reduction in capital expenditure when compared with other systems; facility in putting conducting cables down shafts and laying them underground to distant motors, small loss from resistance in cable or leakage of current to the earth, compared with waste in the compressed-air system; lowness of cost of maintenance; speed with which an electric plant could be erected and set to work. The breakage of a cable and the sparking therefrom was a contingency to be considered. Although the advantages of electricity were considerable, he stated that it was doubtful whether it would be good policy to adopt such a system where steam could be used direct from the surface for haulage purposes; but there did not appear to be the least doubt of the value of electric motors in situations not suitable for other mechanical power.

The Blackening of Incandescent Lamp Bulbs.—"I have repeatedly noticed," writes Mr. W. Stuart-Smith, in the *Electrical World*, "discussions as to the cause of blackening of incandescent lamp bulbs. The latest theory seems to come from France, and is to the effect that residual oxygen in the bulb, together with that which was occluded in the filament, attacks the carbon and forms carbonic oxide, which undergoes dissociation by coming in contact with the comparatively cold glass, depositing the carbon and leaving the oxygen free for a repetition of the process. It has been some years since I have paid attention to chemical matters, but, unless I am mistaken, cooling as above would not cause dissociation, and the above explanation cannot be the correct one. It seems to me that a portion of the action at least must be due to the following cause: It is well known that all substances in the solid or liquid form give off vapour; in fact, are surrounded by an atmosphere of their own vapour. If the substance is confined in an airtight space, the vapour density is definite for every substance and for every temperature, but varies greatly with the temperature, being much greater for high temperatures. For a given substance and a given temperature the vapour density will be the same, no matter what other gases may be present; but if other gases are present in considerable quantities, considerably more time will be required for the density to reach its maximum value. In a vacuum, on the contrary, the action is comparatively rapid. Carbon, when cold, is a very stable substance, and its vapour density very low; but at the high temperature of the white-hot filament vaporisation must be comparatively rapid and the vapour density relatively great. As the hot vapour comes in contact with the cooler glass it will deposit, and thus vaporisation, instead of stopping, as would be the case if the glass were the same temperature as the filament, continues while the lamp is burning. When the lamp is extinguished the vapour in the globe must deposit on the glass until the definite density of the vapour of the cold carbon is attained. The more rapid blackening when the lamp is new may be due in part to the better condensing action of the clean glass, and it may be due in a greater part to the fact that some portions of the filament are more easily volatilised than others, and the action consequently more rapid while these are being thrown off."

REGINALD J. WALLIS-JONES.

Reginald John Wallis-Jones, A. M. I. C. E., M I E E., was born in Liverpool in 1863, and was educated at Christ College, Brecon (under the head mastership of the present Bishop of Bangor), going through a special course of chemistry and physics there. His technical education was then continued by going through the whole course of the School of Telegraphy and Electrical Engineering at Hanover-square; in July, 1881, passed the final examination (first class) in the theory and practice of electric light, telegraphy, and telephones; also passed the speed standards in telegraphy, single-needle Morse mirror and syphon recorder. In May, 1883, he obtained a certificate of first class (honours) from the City and Guilds of London Finsbury College (under Prof. Ayrton) for electric lighting and transmission of power, and also went through the mechanical engineering shops at King's College. Since 1881 Mr. Wallis-Jones has been actively engaged in practical work, first joining the staff of the Anglo-American Brush Company, where he was engaged in the test-room and factory, and then on installation work, such as lighting of Messrs. Peek, Frean, and Co., and the Waverley Station, Edinburgh. He resigned this post to accept the position of inspecting electrician on the staff of Robert Hammond, Esq., and was employed on various contracts, such as lighting of Blair's, Stockton, Bolckow Vaughan, Leslie's Shipyard, Newcastle, etc., and in 1882 came to London for the Hammond Electric Light Company. In 1883 was transferred to the Metropolitan Brush Electric Company; established and managed the Milford-lane central station for them; lit up Covent Garden Theatre; maintained plant of the Royal Mint, Holborn central station, etc. Resigned his appointment in 1884 to rejoin the Hammond Electric Light Company. Among other work, lit up the Theatre Royal, Birmingham, tested all the work for rewiring of the First Avenue Hotel. In the beginning of 1884 was offered an appointment on the staff of Woodhouse and Rawson; superintended for them several important contracts, such as the erection of the first overhead mains for the Grosvenor Gallery electric light station, lighting of reservoirs at Crossness for the Metropolitan Board of Works; contracts for Guinness and Co., Lord Brassey, W. H. Smith and Sons, etc.; and in 1886 went to Portugal for this company to erect plant for the lighting of the Port de Leixoes. In 1887 Mr. Wallis-Jones was appointed engineer and manager of the contract department of Messrs. Woodhouse and Rawson, Limited, and went to Barcelona to design the system of electric lighting for the central station there. He has designed and patented several improvements in electrical apparatus, such as an automatic earth detector, recording voltmeter, fuses, surgical lamps, etc.; and in conjunction with Mr. Stepney Rawson compiled the well-known "Woodhouse and Rawson wiring table." In 1882 Mr. Wallis-Jones was elected an associate member of the Institute of Electrical Engineers, and in May, 1889, was elected an associate member of the Institution of Civil Engineers, while in 1889 he became a member of the Institution of Electrical Engineers. His connection with the Old Students' Association is well known. In 1888 he was awarded the medal of the institution for the best paper of the year, which was entitled "Some Installation Breakdowns." In the beginning of session 1890-1 he took up the work of honorary secretary to the association, and the following figures speak for themselves as to the work done: "Last session 62 new members were elected," and up to December 31, 1891, the date of his resignation (the session ending in October, 1892), 38 members and associates were elected. In December, 1891, owing to pressure of professional work, Mr. Wallis-Jones had to resign the honorary secretaryship. Since the failure of Woodhouse and Rawson, Mr Wallis-Jones has been connected with Messrs. Waller, Manville, and Kincaid.

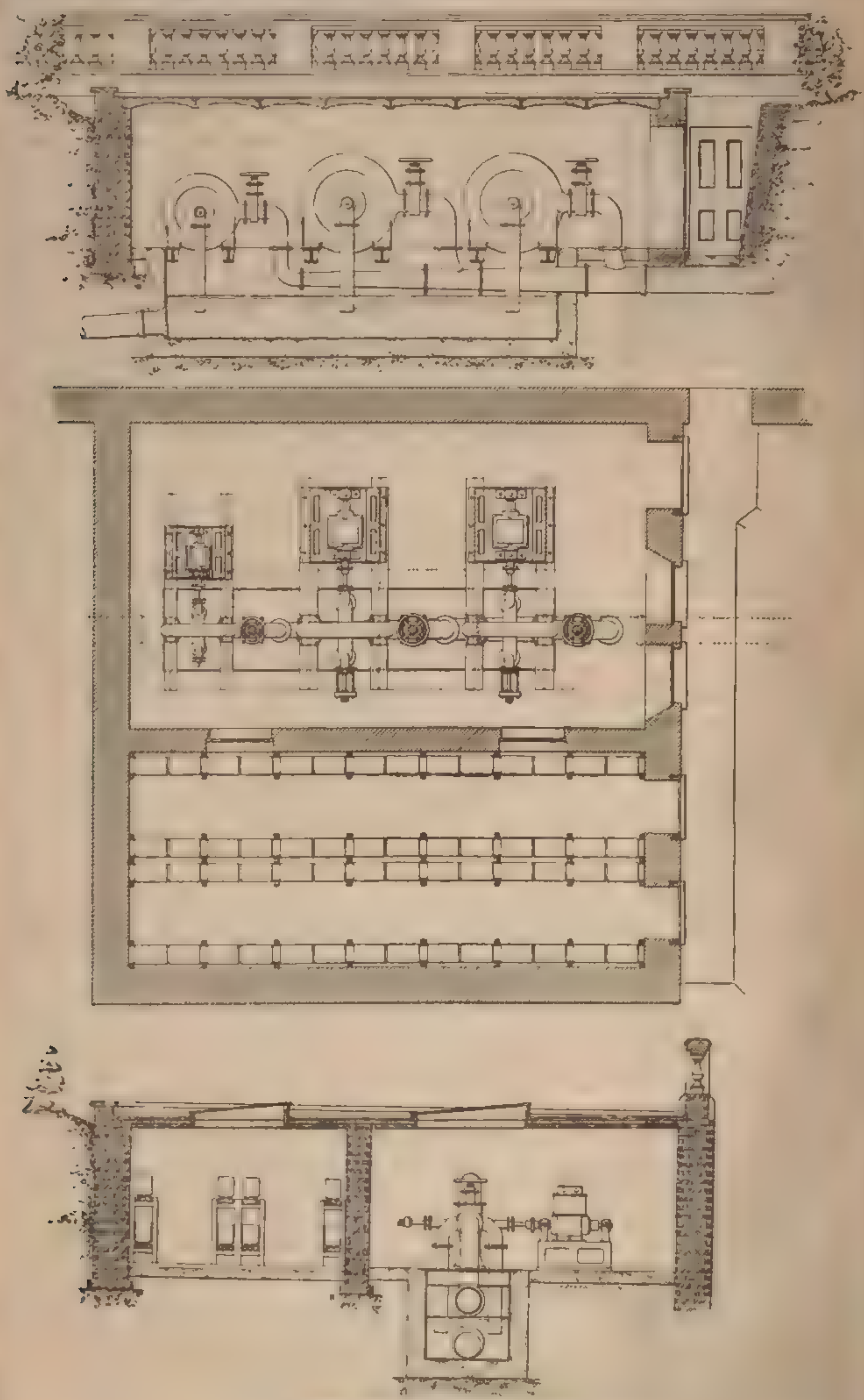
ELECTRIC LIGHTING AT CHATSWORTH.

We have been favoured with a brief description, with illustrations, of the installation designed by Mr. B. Drake, and carried out by Messrs. Drake and Gorham, at the historic mansion of Chatsworth. It has been Mr. Drake's object to reduce the whole arrangement to one of absolute simplicity, as he attributes his success in the large number of country house installations which he has laid down to the elimination of any complicated apparatus which is likely to become deranged. He contends that it is always more easy to arrange a complicated apparatus than a simple one, and it will be seen that at Chatsworth the whole of the lighting requirements of a large country house have been met, and the plant is so simple that no skilled labour is required in its manipulation.

At a height of some 400ft. above Chatsworth House there exists a lake of some nine acres in extent, to which a pipe was laid some years ago for the purpose of supplying water to the well-known Emperor fountain. Mr. Drake found that by tapping this pipe he could obtain up to 150 h.p., or sufficient for all the lighting required. The turbine-house has been excavated entirely out of the solid ground, and being surrounded by shrubs it is entirely out of view from every side. Provision is made in the turbine-house for two turbines, each of 50 h.p., and one of 20 h.p., of which the third turbine is not yet completed. The dynamos are coupled direct to the turbines, forming a very neat and compact arrangement which is not likely to become deranged. From the dynamos the current is conveyed to switchboards, by means of which the supply from the house can be drawn from either of or all the turbines according to requirements.

Adjoining the turbine-house is the accumulator-room containing 60 accumulator cells for supplying the requirements of the house when the turbine is not at work. These cells are charged from a separate machine during the hours of lighting, so as to reduce the item of labour to a minimum. To avoid the complications due to the supply of current from a dynamo which is charging the accumulators owing to the rise of E.M.F., according to their state of charge, the switchboard has been arranged so that the small machine can be employed for charging the accumulators, while the house circuit is run direct from the larger machines, which are connected either singly or in parallel as required. The arrangement also provides for the small machine and the accumulators being worked together in case of emergency for the supply of the house. Precautions are taken in the switchboard to prevent any accident due to the switches being moved in the wrong order. Owing to the high fall available, special precautions had to be taken to prevent any sudden stoppage of the water which would produce a jar on the pipes. A previous attempt to provide a valve at the lower end of the pipe so as to avoid having to climb the mountain whenever the fountains were required, has entirely failed from this cause. To meet this, a 3in. by-pass is provided for every valve, so that after the main valve has been closed the by-pass can be manipulated. This expedient has been found to be thoroughly successful.

The turbines used are of the Vortex type, by Messrs. Gilkes, of Kendal, and arranged to run at 1,000 revolutions per minute, the dynamos being manufactured by Messrs. Siemens Bros. The roof of the station is composed of concrete, carried by iron joists, and the whole plant runs so noiselessly that at the distance of a few feet from the turbine-house it is impossible to tell whether it is running or not. In addition to the pipe which carries away the water from the turbines, a large safety opening has been arranged to guard against any accidental flooding of the turbine-house.



CHATSWORTH ELECTRIC LIGHTING

The current is conveyed underground, by armoured cables more than ½in. sectional area, to a point in the centre of the building, from which the whole distribution to the different rooms is effected, every circuit being carefully numbered, so that it can be controlled at will. There are also switches placed throughout the building in convenient places so as to take full advantage of the ease with which electric light can be lit or extinguished. The voltage at the house is maintained at 105, and the whole of the wiring is on the parallel system. The accumulators are of the "D. P." type, capable of discharging at 120 amperes for four hours

In the general arrangement of the lighting Mr. Drake's object has been to utilise all the handsome old fittings, for which purpose a special imitation electric candle has been introduced, which so nearly resembles wax in colour and texture that it is impossible to distinguish the two when placed side by side. Where fittings have been added, the style of each room has been carefully studied and the fittings made to harmonise with the architectural requirements, the metal work being entrusted to Messrs. Hart, Son, and Peard. In many of the rooms, such as the oak-room, where metal work would have been out of place, the lamps have been skilfully embedded in oak carving worked into the orignal panels, by which arrangement the lamps are almost invisible in the daytime.

WHAT IS ELECTRICITY?—VI.

BY SYDNEY F. WALKER.

THE ATTRACTIONS AND REPULSIONS OF ELECTRIFIED BODIES.

Though every part of this subject is very difficult, at first sight probably that portion which the writer has chosen for the subject of the present article presents more than the usual share of difficulty, because, apparently, the phenomena of the attractions and repulsions of bodies electrostatically charged stand quite apart from the other electrical phenomena with which we are familiar. These phenomena would appear also to be in somewhat the same category as those presented by the force of gravity, in that we have only been able to say hitherto that they existed, without explaining why they existed. If it should prove that the theory is correct which the writer has ventured to put forward as accounting for the various electrical phenomena, may it not be possible that the line of thought induced may lead us even to the explanation of the causes of the force of gravity itself?

If the views which the writer has enunciated are correct, it follows that everything in the universe may be referred to two elements—matter and energy; and that every substance we know of, every substance that exists, of whatever form, has taken the form conferred on it by the energy present—in other words, in accordance with the resultant of the forces present. In a non-electrified body, we have not a body at rest—there can hardly be such a thing in nature—but a body already in motion within itself, whose molecules are in motion, and not only in motion, but subject to different kinds of motion, in obedience to the different forms of energy already present. Thus, in the leaves of a gold-leaf electroscope, the gold leaves themselves, though apparently at rest, have their molecules in motion, due to the heat present, to the light-rays that are absorbed, possibly to sound-waves passing through them, and, further, to the motions to which they owe their being as molecules of the substance we know as gold. Further, the bodies around the gold leaves are not at rest. The metal conductor to which they are attached, the glass bottle that contains them, the atmosphere surrounding them, both within and without the bottle, all are subject to the same forces, all have their molecules in motion from the same or similar causes. And, as we know, the position of outward rest assumed by the gold leaves is taken up in obedience to the resultant of all the forces present, of the forces that have been described, and, in addition, the force of gravity, the pressure due to the weight of the surrounding atmosphere, and others.

The position of outward rest is a position of equilibrium so long as the forces present remain in the same proportion. If you alter any one of the forces present, if you bring another force to bear upon any part of the system, the equilibrium is destroyed, and you may have outward motion till a new resultant furnishes a new position of rest or equilibrium. If you cause a draught of air to be directed towards the gold leaves, they will be deflected both to one side or the other, or in opposite directions, according to the direction and force of the draught employed, till a new position of rest is found. If you pass a sound-wave through the gold leaves, say, by connecting a sounding body to the table of the electroscope, motion again results, though not in the same form. If you pass heat into the gold leaves, adding to the heat already present, motion again results, though, again, not in the same form as when you applied your draught of air. And so you may cause motion of the leaves in a number of different ways whenever you produce sufficient alteration in the position of equilibrium to cause motion of translation—motion from one position of rest, as we view it, to another.

One method, then, should be, if the writer's view is correct, that what we know as electricity is motion, to pass a charge of electricity into the gold leaves, and, as everyone knows, the result of such an operation is to cause a motion of the leaves, to cause them to diverge from each other. In this, as in each of the other cases, what we have done is, we have added a new motion, not only to the gold leaves, but to the atmosphere surrounding them, and to every body in the neighbourhood. In obedience to this added molecular motion, which is strongest in the metals because they are metals, because they are created to receive this motion we call electricity, and the other motions we call heat and sound, more readily than other bodies, weakest in the atmosphere surrounding the leaves and in the glass containing them, for the contrary reasons, visible motion of the gold leaves follow. We have added the same motion, and in even a larger proportion, to the metal conductor supporting the gold leaves, but no motion results, because the other forces present did not allow it. The gold leaves are more easily moved, because the effect of the other controlling forces, such as gravity, upon them is small. If we apply a controlling force of sufficient magnitude to resist the electrostatic force applied, we shall obtain no motion of the leaves, as, for instance, if we place the electroscope within a vessel containing air or other gases compressed above the ordinary atmospheric pressure. On the other hand, if we reduce the pressure of the atmosphere within the electroscope by creating a partial vacuum, we shall obtain an increased motion, other things being the same, for a given expenditure of electrical energy.

Again, as we know, if the temperature of the conductor of our electroscope is very low, we shall have difficulty in obtaining a divergence of the leaves, while if it be well heated first we obtain a divergence with comparative ease. What we do, then, when we charge an electroscope is to communicate motion, added motion, to all the bodies present; and this motion, expending itself on the molecules of the body, causing them to move not only within the body, but, in doing so, to expand the body, and the conditions being favourable to move it as a whole, causes the divergence we are familiar with. Just as the application of heat will cause light bodies—gold leaf, tissue paper, etc.—to move as a whole, so the application of what we call electricity to similar light bodies causes them to move—not in the same manner that the application of heat moved them, but strictly in accordance with the resultants of the whole of the forces present.

The above reasoning holds good for other light bodies—such as pith balls, feathers, the puppets that are made to dance by electrostatic charges, and others. The question of the attraction of oppositely electrified bodies for each other the writer hopes to deal with in the next article.

Edison Phonographs.—The Edison-Bell Phonograph Corporation have obtained an injunction against the Edison Phonograph Company, restraining the latter from infringing Mr. Edison's patents by the sale and use in England of a phonograph imported from America, and said to be made in accordance with the patents.

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THE DAYS THAT ARE PAST.

The end of each year is, of course, an excellent "sermon time," and few persons are lucky enough to escape the outpourings of moralisers upon every subject and theme. The "gentle reader" will therefore doubtless be ready with due allowance of Christmas charity (or not, as he thinks fit) when he looks on this page expecting to find the customary number of paragraphs containing each a nice little moral wrapped up in a modicum of interest, wit, and wisdom. At the worst, then, we shall only try his patience more or less—perhaps, let us hope, rather less than more.

Seriously, however, those engaged in the electrical industry of Great Britain—to whom these columns more especially appeal—can and will of a certainty look back upon the past year as being the most important that they have hitherto seen. On the one hand, trade in general ebbed and flowed and ebbed again to a point in the curve of commerce whose equation is perilously near $\frac{1}{x}$; and, as a rule, when the volume of business sinks, or tangible profits grow small by degrees and beautifully less, the merchant, the manufacturer, the warehouseman, and the shopkeeper, with all their allies of industry, are obliged to cut down expenses to suit. If, therefore, electric lighting had not ceased to be a luxury, and attained the greater height of being an absolute need to suffering humanity, we should have seen a very considerable diminution in the amount of work accomplished in 1893 as compared with that of the previous year or two. But it is safe to say—even in the absence of definite reports from the firms and companies engaged in the trade—that capital progress has been made, and a considerable amount of solid work accomplished, the results being perhaps more satisfactory in proportion as the unreliable, badly managed, and thriftless concerns have dropped out of the struggle.

It might be of some interest to a few if we were to tabulate the actual progress of 1893—say, with regard to central-station work and the development of public lighting; but just as the figures in a charity sermon respecting the number of orphans to a fraction relieved per diem, etc., are not nearly so attractive as the rows of bright young faces themselves, we may leave the task, at any rate for the present, to the industrious compiler of illusory and incomplete statistics. He is certain to arise at an early date in the new year with promptitude only surpassing those others who hasten to contradict him. Figures, it is said, can never lie, though according to the gas journals (who for some curious reason entertain a feeling of jealousy towards electric lighting), the converse—that liars can figure—holds equally well.

There is, of course, one pre-eminent feature in the past year that has already began to effect progress of a type even more marked than the steady advance of the previous twelve months; but the subject of incandescent lamps, the expiry of patents, and all the rest of it, has become as cheap as the two-and-a-half watt twenty-five-for-a-sovereign lamps themselves; and not even an end-of-the-year moralising article will stand any more of it.

Enough now to say that, so far as mortal mind can postulate the course of affairs, we see at the present time the industry of electric lighting established not only *firmly*, but almost *freely*—that is, without any restraint but that of open and fair competition. So long as these conditions exist, we feel sure of continued trade prosperity in this direction for many years to come. Such prosperity may not—we hope *will* not—be too rapid of development: we have had a surfeit of 25 per cent. dividends paid (or, rather, declared) out of capital. The promoter (we use the word in its best sense) of electric lighting enterprises will be well advised if he keeps to a modest 5 to 10 per cent. return upon his capital; and this applies still more when the promoter is a public body.

Is it, we wonder, within the bounds of possibility that as we have thus written of electric lighting prospects—"front and back," as the Irishman said—so we may at the end of an early year also write with regard to the developments of electric traction and power uses generally? It would seem almost inconceivable that we should be able at the close of each year to chronicle great advances in electric lighting, whilst the equally wide-reaching developments of power distribution are almost non-existent. To-day, however, there is little or no progress to report in traction work. Early in the year came the opening of the Liverpool Overhead Railway, but since then the actions of the electric traction interests have been less prominent than their talk. Possibly the tongue in this case must precede the hand, but joint committees, or even modified draft rules from the Board of Trade, will never build or equip a tramway, although they may prevent its being done. Isn't it about time, good gentlemen, to get to work: and as soon as the ground is clear, and the "powwow" finished, may we not hope to give the horse a rest from his labours, so far as tramcar hauling is concerned? We do not, at any rate, expect to be satisfied with electrical progress until the "days that are past" have seen the opening ceremonies of more than one electric tramway, or other system of power distribution and utilisation.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

PROF. FORBES ON HIS CRITICS.

SIR,—As you are probably aware, I am not in the habit of answering anonymous personal attacks, but, in view of the possibility of other people sharing the opinions expressed by some of your contemporaries affecting my character for fairness, I beg leave to ask for space to publish one or two facts in your valuable and impartial journal. My critics have, without seeing the designs of Mr. C. E. L. Brown, endorsed the opinion that, in designing a 5,000-h.p. alternator, I have availed myself of the plans submitted by him to the Cataract Construction Company. I am quite sure that Mr. Brown would corroborate the statement that the general features of the designs are totally distinct. But my critics particularise the charge by saying that I have taken from Mr. Brown's design the idea of winding the armature with copper strip, insulated with mica. Is it claimed for Mr. Brown that he is the originator of such a proposal? Mica insulation is largely used in the States; and further than this, I have in my office the drawings of the first 5,000 h.p. alternator which I designed long before Mr. Brown got out his design, in which the winding above referred to was adopted. In my latest design, however, it happens that the armature is wound with cotton-covered copper wire, No. 0 B. & S. gauge. It is true that the fields are wound with copper strip, but the insulation is tracing-cloth. I submit that there is not the slightest foundation for the charge which has been made.

With regard to the charge made by Mr. Ferranti against the Cataract Construction Company, and supported by Mr. Crompton, in his usual courteous and gentlemanly language, by saying "that there had been a barefaced attempt to pick the brains of the world," it would be hopeless to ask whose brains they have picked, and what details of the system are due to them; but from the moment that the suggestion of such a charge was hinted at to me by Mr. Ferranti, I have looked into the matter, and the following statements are true:

1. With the design sent in by Mr. Brown there were two prices—one for the machine made in Switzerland, another for working drawings, with the object of manufacturing in America.

2. If the design of that gentleman, or any other manufacturer, had been thoroughly suitable for our case, that design would have been accepted, and the price quoted paid for it, whether it was made in America or Europe.

3. The Niagara enterprise is probably the first American enterprise that ever came to Europe, saying, "We have already subscribed our capital in America, and we are ready to exchange such portion of our cash as may be necessary to secure the brains to properly conduct our enterprise." I confess I am ashamed of my countrymen, and cannot imagine what is the animus which has led to so wilful a misconstruction of such liberality, foresight, and straightforward dealing.

4. It has been generally understood that no private undertaking has paid so much for engineering advice, in advance of contracting, as the Niagara project. Most of these disbursements have been made to English, Swiss, and French engineers, and they amount already to about 90,000dol.

These are facts from which your readers may form their own conclusions as to the animus which has actuated the critics of the Cataract Construction Company.—Yours, etc.,

GEORGE FORBES.

Westminster, S.W., December 27, 1893.

SHUNTS.

SIR,—I am greatly obliged to your correspondents "Sidney F. Walker" and "Sidelight" for the information they give me in connection with my difficulties, and also to you, Sir, for your remarks, which, to say the truth, are not much to my liking. Let me deal first with your reference to a contemporary, and that contemporary's reference to my letter. I may say that I never buy that contemporary, and I never met a man who did. I get it sent gratuitously, like most members of the industry, and think it a very wisely-conducted concern; better than a trade catalogue, because ordinary folk do not know how it is run and why certain interests are kept to the fore while others are in the background. But the trade knows, and laughs. Grub-street still exists, and writers can be bought and sold. This contemporary, with that flippancy so characteristic of it, says, "Of course, a shunt to a galvanometer always acts by lowering the difference of potential," etc. "Of course"—that is the usual flippant introduction. But "of course" is not found in the text-books, and I doubt if any scientific man of repute will be so ready to corroborate this "of course." If your contemporary is correct, perhaps it will indicate some text-book or some authority from which I may gain a little more information on this "of course." Perhaps it will be able to prove that practical folk do, after the insertion of a shunt, change the arithmetical value of the original E to something else, E_1. The

original formula is, say, $C = \frac{E}{R}$; putting in the shunt decreases R to R_1, and according to your critic changes E to E_1, so that we get a new formula with all three quantities varying, and $C_1 = \frac{E_1}{R_1}$. So far, all is good; but how am I to know what the new E_1 is to be? I cannot find any text-book that tells me to measure E_1. The fact is, your contemporary tells me that I am to find two unknown out of three; for C_1 is unknown, and, according to it, E_1 is unknown, and I only know R_1. Well, my mathematical knowledge is too feeble to tell me how it is done. Won't your wise contemporary just tell us? It is so knowing, and lays down the law so cavalierly, that it must know some book or paper which will help me. Let me put this case. I have a secondary battery with internal resistance practically negligible, and connect my galvanometer directly to its terminals by a negligible resistance. The pressure acting on the galvanometer is indicated by E. I now insert a shunt, say, of equal resistance to the galvanometer. Is the acting pressure, E, changed to E_1; and what is E_1? I find no text-book to tell me that E changes to E_1, and have always used formulæ similar to the following: (1) $C = \frac{E}{R}$; (2) $C_1 = \frac{E}{R_1}$; when E and R in (1) are known, and E and R_1 are known in (2). If E changes to E_1 in (2), in what text-book shall I find it explained? It is holiday time, and I cannot write more at present, though in another letter I hope to illustrate by means of a diagram what I understand takes place. Wishing you and your contemporary—which, though I hit at, I have a sneaking affection for—all the compliments of the season.—Yours, etc.,

H. L.

THE DYING OUT OF ALTERNATING-CURRENT WAVES.

BY A. E. KENNELLY.

It has been asked how many times an alternating current could be transformed through successive induction coils without losing its essential wave character.

If the induction coils have no iron cores, the case depends entirely upon the shape of the wave of E.M.F. impressed at the terminals of the first transformer. Supposing that this wave were sinusoidal, then after the permanent state of steady activity had been attained, all the currents and voltages throughout the series would be sinusoidal. There would be attenuation and change of phase along the series, but there would be no change of wave type, whatever the resistances, capacities, or inductances might be, provided these did not vary with time.

If the wave of E.M.F. impressed upon the first transformer were not sinusoidal, then, with iron still excluded, there would be a progressive change of wave type accompanying the attenuation and phase displacement. The change would be rapid in the earlier and more gradual in the more remote transformers. The finally surviving waves after an indefinitely great number of successive conversions, would be fundamental sinusoids *i.e.*, simple harmonic waves of the alternation frequency. The exact rate at which deviations from the sinusoid are absorbed depends upon all the conditions of the successive circuits, but is open to computation when these data and the initial wave outline are forthcoming.

If, on the other hand, the induction coils contain iron, new considerations arise. There will now be hysteresis and variable magnetic leakage to take into account. Owing to hysteresis, the currents will not be sinusoidal even if the first impressed E.M.F. be sinusoidal, and owing to this the drop of pressure in resistances will introduce a departure in the voltages from the simple harmonic type. The magnetic leakage, which varies during the cycle, also causes some deviation of a similar nature. But while this disintegrating influence is extending, there will also be a correcting tendency at work such as would be established by transformers without iron. Which of these tendencies will preponderate, whether the waves would become more and more distorted along the series, or more nearly sinusoidal, would depend upon all the circumstances of the circuits, of the quality of iron in the cores, and of the initial wave outline, but under ordinary conditions it would seem that the waves would never become truly sinusoidal, but would also never undergo great distortion.

Briefly, then, non-ferric induction coils would, in the permanent state, transmit an initial sinusoidal wave through an indefinitely long series of such coils, unchanged in type. They would also sift an initially non sinusoidal wave down to a sinusoid, so that practically the conditions might then be closely represented by a sinusoidal generator of reduced amplitude brought into operation further along the line, beyond the principal sphere of shifting action. With ferric transformers the case would be more complex, but, broadly, there would be a tendency for the sinusoid to survive.—*Electrical Engineer* (New York).

CHLORIDE ACCUMULATOR.

We have referred to this accumulator several times, and now give diagrams of the plate and of curves obtained. It will be unnecessary to enter fully into its composition, as this information will be found in our issue of November 17, page 461. Fig. 1 shows a plate, while Fig. 2 shows the curves obtained.

FIG. 1.

The diagram of curves shows the capacity of the chloride accumulator under varying conditions. These curves show the results of various tests. It will be seen by comparing

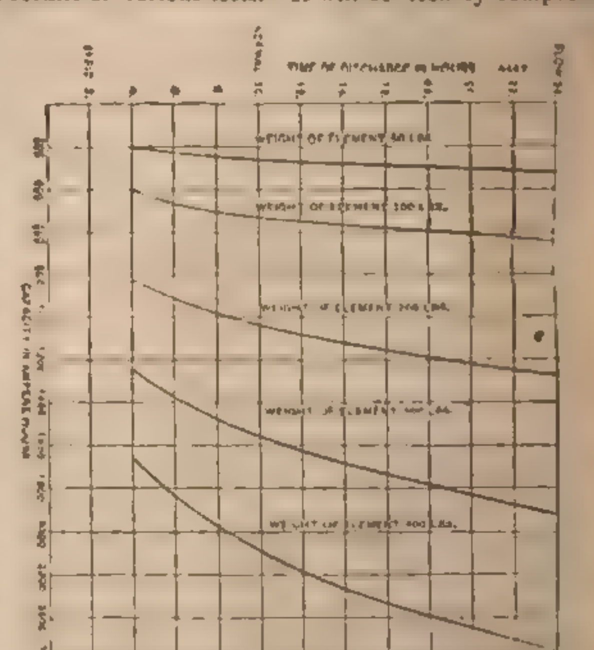

FIG. 2.

the different results that in every case there is shown to be a difference in capacity of only one third between the lowest and the highest rate of discharge. Thus, while the smallest element, weighing 50lb., has a capacity of 320

ampere-hours when discharged in 24 hours, its capacity is still as high as 210 ampere-hours when discharged in four hours, which is six times its previous rate.

UNIPOLAR AND NON-POLAR INDUCTION.

A paper on the subject of unipolar and non-polar induction has been read before the Electrotechnical Society of Berlin, by Mr. Friedrich Vogel, of Charlottenburg. The author referred to a paper on the subject of unipolar machines by Mr. Thom. Marcher, previously published in the *Elektrotechnische Zeitschrift*, which accorded in the practical results with experiments previously made by the author. The explanation given by Mr. Marcher of the behaviour of the magnetic lines of force, however, appeared to Mr. Vogel to be incorrect. The experiments carried out by the latter gave results which, although sufficiently

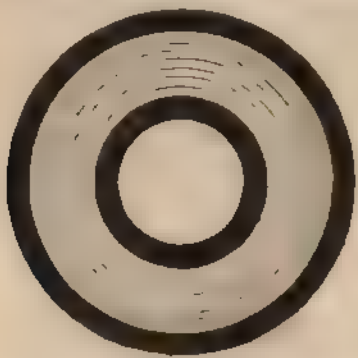

FIG. 1.

interesting theoretically, greatly reduce the value of unipolar machines for high tensions. In any case the unipolar machines, according to the French patent No. 181,787, the German patent No. 50,805, and the recent German patent application 72,048, and others, were theoretically wrong.

The author mentioned that, starting from a similar standpoint to that of Mr. Marcher, he himself tried to construct a practical unipolar machine. This, however, would not work.

The description of the experiments is so presented that a start is made from a machine which corresponds in principle with the foregoing patents, and then passes on to the changes conceived by the author, from which working results could at least be hoped for, if not expected, and finally deals with the experiments which allow of a definite decision respecting the course of the magnetic lines of force in the rotating armature.

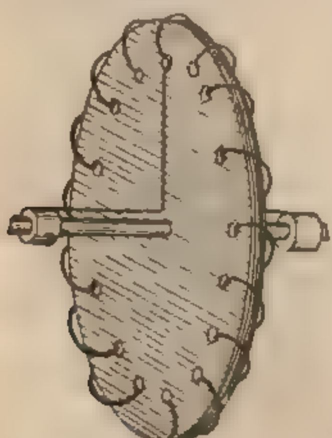

FIG. 2

Fig. 1 shows a plan of one of the magnets lying at the side of the armature. A disc of iron plates served as the rotating armature, which was bored in such a manner that the perforations lay in a circle concentrically to the axis of rotation and between both ring poles. The windings were led through these perforations—about 120—which continued in the style of a Gramme ring, and lay before the outer ring pole. The ends of the windings were led past the inner pole, as shown in Fig. 2, along the shaft of the machine to the commutator. The resistance of the armature winding amounted to 0·45 ohm.

We give one series of experiments which took place at the works of Messrs. Siemens and Halske at Charlottenburg. Accumulators were employed to excite the magnets, and a torsion galvanometer of one ohm resistance for measuring the current. The output of current at 2,500 revolutions was 0·006 ampere, and from this is calculated, with a total resistance of 1 + 0·45 ohms, an E.M.F. of 0·0087 volt.

In place of the whole winding a single wire was laid, which, as shown in Fig. 3, ran longitudinally with the axis through a perforation. The inner resistance of this wire could practically be left out of account. With this,

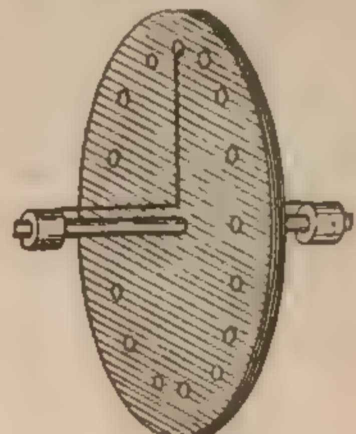

FIG. 3.

at approximately the same rate of speed and the same magnetisation, the output was 0·0082 ampere, or 0·0082 volt, or pretty nearly the same E.M.F. as the whole winding. In both cases the E.M.F. could only have been induced by the lines of force passing beyond the inner ring pole, and acting by induction on the leads to the commutators. If this supposition were correct, it would be necessary to strengthen the induction in order to improve the magnetic circuit from the shaft to the magnets. In order to obtain this improvement, screw keys were held on the bearing-pieces and back plates of the magnets, either towards only one magnet or towards both. The result for the whole winding at 2,500 revolutions was: 0·0063 ampere with a single and 0·0069 ampere with a double winding; the result with a single wire at 2,600 revolutions was 0·0082 ampere, and 0·0087 with a double.

Experiments hitherto have left it doubtful whether the E.M.F. is nil in the winding, because the armature iron, which contains perforations, takes with it the magnetic lines of force which pass from the closed-ring surfaces out-

FIG. 4.

wards through the armature iron, or if there be another cause. The author consequently caused to be made by the same engineer, Mr. Richard Galle, who had made the previous magnets, a pair of magnets, the circular dimensions of which were the same as those of the former, so that they suited the same armature. They differed, however, from those used in the first tests, as shown in Fig. 4, inasmuch as the pole surfaces were not continuous rings, but alternated

broad pole surfaces, with intervening spaces, which were cut in down to the back plate. With this arrangement, a pole surface on the inner crown always stood on the same radius as an intermediate space on the outer crown. The same coils as before, served in all the following experiments for the magnetic excitation, so that all the pole surfaces of the inner crown were of the same polarity as well as those of the outer crown. The armature iron furnished with perforations could no longer, therefore, take with it the lines of force, as the field magnets were also perforated.

From the experiments carried out it appears very unlikely that the failure of the previous unipolar machines with multiple winding is due to the magnetic lines of force being carried away by the armature iron. The result of the experiments is rather as follows:

The magnetic lines of force remain between the polar surfaces from which they spring. In the rotating armature iron the lines of force must go round about the perforations, thereby being torn away and causing eddies. These torn away lines of force induce in the parts of the conductors, which pass through the perforations in order to form a connection between the portions of the conductors led to the pole surfaces, exactly as high an E.M.F. as in the outer portions of the conductors, and they counteract each other.

A priori, this result is not quite to be understood. The lines of force only go to a small portion, corresponding to the specific magnetic resistances, through the perforations, and cut the conductor-pieces lying there. When the field-magnet poles consist of homogeneous rings or other revolving bodies, the distribution or field of force in the armature iron remains the same; yet the same acts by induction.

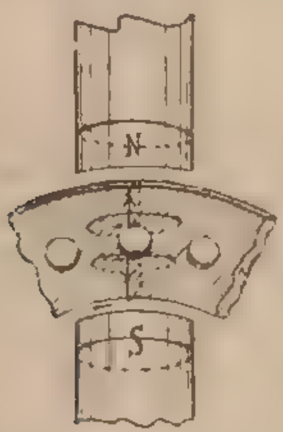

Fig. 5.

When the lines of force in the armature iron — as before, homogeneous pole rings — are in a stationary condition, the molecular currents travel from molecule to molecule at a constant rate of speed. It can easily be shown, in Fig. 5, that the forces which originate from those parts of the conductors carried through the perforations from the lines of force set up by the current in the armature iron, exactly counteract the forces which act between the outer portions of the conductors and the pole surfaces. In Fig. 5 the dotted lines indicate the portion of the conductors lying behind the plane of the paper, referring to circuit currents substituted for the magnetic lines of force. The direction of the current is shown by arrows on the conductors. As the forces counteract each other, there is no working output when the armature is rotated. Therefore in the whole winding there will be no current induced, nor can this, if furnished with current, work as a motor.

The author next returns to the substitution of the lines of force relative to the bodies magnetically excited by a circuit current in connection with non-polar induction.

The only working force which is exercised upon a complete winding or armature when current passes through it from the magnetic system, field magnet, and armature iron, is that the winding seeks to place itself parallel to the pole surfaces, and therefore perpendicularly to the direction of the lines of force. This working force, however, shows itself merely as pressure on the armature iron, not as turning momentum in the direction possible for the armature to move as tangential force.

The author made the following experiments at home which leave little room for doubt. He used a mirror galvanometer of his own construction, of high resistance and very sensitive, as the instrument for authenticating the resulting E.M.F. The magnets were excited by an accumulator. The field magnets employed were the same as before. On the one occasion those with continuous ring poles were used, and on the other occasion those provided with intermediate spaces. No difference was shown in the qualitative behaviour of the two magnets.

In place of the armature already referred to, the author made a new one, in which he used massive copper discs for the winding. These were insulated from the armature iron, and also from the shaft, and were screwed up to the armature core, consisting of discs made of iron plates.

The copper discs were somewhat amalgamated at the outer sides, so that the current might be better conducted. For taking off the current two systems of brushes were used, made of woven wire. One of these was in contact with the outer circumference of the copper discs, and the other in the middle between the outer pole and the inner pole, opposite the former.

In the first experiment the iron discs and the two copper discs had no perforations between the poles. It was very easy to collect current from each copper disc, and to prove that an E.M.F. was produced. This experiment corresponds completely with the Faraday induction in copper discs iron armoured. The E.M.F. of the two copper discs could also be placed in series.

In order to discover what influence a greater interruption of the armature iron would have on induction, the iron plates were perforated, while the copper discs were left untouched. The perforations lay about midway between the outer and inner poles. The result of the experiment was exactly the same as before.

Next, the copper plates were connected with each other by means of rivets passing through the perforations already made. If, now, the two E.M.F.'s in the two copper discs were not counteracted by a third formed in the rivets passing through the armature iron, they must be able to be put into series as soon as they were both connected at the brush system at the circumference with the galvanometer.

Fig. 6.

No working was, however, perceptible. On the other hand, when the two inner brush systems were connected by the galvanometer, the E.M.F. in the rivets could be proved.

The practical result arrived at by the author is the same as that of Mr. Marcher—viz., that all unipolar machines have hitherto rested upon false principles, in which an addition of E.M.F. in single parts of the conductor is striven against by leading the winding according to a Gramme ring through parts of the armature iron. As a theoretically interesting result, the author considers that the demonstration showed that, in fact, the magnetic lines of force continue through the iron, or, in other words, the analogy founded by W. von Siemens between magnetic occurrences and electric currents is the correct one (and confirms their introduction in the calculation of magnetic phenomena), and not the analogy with electrostatic influence.

The author also touched upon the non-polar induction in Faraday ring transformers, as the statement concerning the same by Mr. Marcher did not appear to be correct. The author starts from an induction coil, Fig. 6, the interior of which may or may not contain an iron core.

If a closed-circuit current be moved in even line in the direction of the axis of the coil out of the infinite to the position A_1, then the force exerted by the coil on the circuit current increases, and reaches its maximum in the neighbourhood of A_1, because here all the windings of the coils work in the same way in the direction of the movement. In the position A_2, on the other hand, the forces in the direction of the movement are counteracted as the circuit

current lies symmetrically to the single windings of the coils. The sign of the working of force changes from over this position. If the induced electric work be regarded as the equivalent of an applied mechanical work, then follows the known behaviour of the E.M.F. The forces are strengthened when bodies which can be magnetised are placed in the coil, as the resulting currents strengthen the working of the coil currents. The E.M.F. is therefore strengthened, but remaining nil in the position A_2.

The closed-circuit current does not behave the same if it be not moved parallel to the coils; but in the latter case the strength of current varies. In the position A_2, the forces parallel to the coil are nil; but forces work on each line element or circuit in the direction of the connecting line with the axis of the coils—these try to draw the circuit current together, and therefore to lessen the circuit, or *vice versâ*.

Consideration is next given to a ring inductor, which may have over all its circumference an evenly-distributed exciting winding, as shown in Fig. 7. In the same way as with a straightly-stretched inductor, a working of the exciting current is strengthened by the ampere molecular currents. The latter are replaced by the resulting currents, which pass concentrically to the exciting currents.

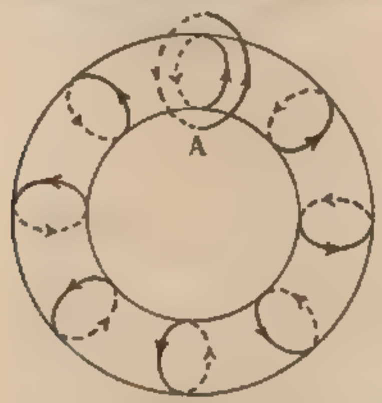

FIG. 7.

A circuit current, A, is found at the ring inductor in each position symmetrically with the circuit currents of the ring. Consequently, there is never exercised on the circuit current, A, any force in the direction of rotation round the axis of the ring. Consequently, no induction can take place in a circularly-arranged conductor if the conductor revolves round the ring.

It is obvious, however, that forces operate on the circuit current, A, which always fall in the level of the circuit current. Induction is also obtained if a wire loop is laid round the constantly excited ring, and the same be pulled together or pushed apart.

If changeable magnetisation lie under the ring, induction is set up in each circular-shaped piece of conductor which is laid on the ring.

The magnetic lines of force fill not only the iron of the ring, but also the surrounding space of the circuits of which the central points have their geometrical position in a plane which stands perpendicularly on the level of the ring at its middle points. If the excitation be changed, then the density of the lines of force is altered.

CYLINDRICAL COPPER CONDUCTOR RESISTANCE OF ALTERNATING CURRENTS.

In 1886, Lord Rayleigh gave a formula to calculate the effective resistance of a conductor of circular section through which an alternating current of given frequency passed. Unfortunately, the series which gives these values is so little convergent with the increase of the diameter and the frequency, that it is practically useless.

In his presidential address to the Institution of Electrical Engineers in 1889, Sir W. Thomson gave a table calculated for certain diameters and a frequency of 80, which extended the radius for practical work. From a practical point of view it is handy to have a table which will enable us to make the necessary calculations for all diameters and all frequencies, hence M. Hospitalier has in *L'Industrie Electrique* attempted to give a simpler formula and figures to facilitate calculations.

Let R_A be the resistance of a conductor with circular section carrying alternate currents, and R_c its resistance to continuous currents, then

$$R_A = k\,R_c.$$

where k is a numerical coefficient depending upon the frequency, $\frac{1}{T}$, and the diameter, d.

From Sir W. Thomson's researches it is found that for a given conductor this factor, k, is the same for each value of the product $d^2\frac{1}{T}$, whence it is possible to give in tabular form the values of k for each corresponding value of the product diameter by frequency. In the table given below diameters are in centimetres and frequencies in periods per second, the conductor being copper with a resistivity of 1,597 C.G.S. units. In order to get the factor, k, of a conductor, d, cm. in diameter, it is sufficient to multiply the square of the diameter by the frequency in seconds, and to find in the table the approximate value of k, which is then to be used in the equation.

VALUE OF COEFFICIENT k, with copper conductors of circular section of diameter d (cm.) traversed by alternate currents having a frequency of $\frac{1}{T}$ (periods per second):

$\frac{d^2}{T}$	k.	$\frac{d^2}{T}$	k.
0	1·0000	1620	1·8628
20	1·0000	2000	2·0430
80	1·0001	2420	2·2190
180	1·0258	2880	2·3937
320	1·0805	5120	3·0956
500	1·1747	8000	3·7940
720	1·3180	18000	5·5732
980	1·4920	32000	7·3250
1280	1·6778		

Example.—What will be the effective resistance of a copper conductor 2cm. diameter traversed by an alternate current of which the frequency, $\frac{1}{T}$, is 80 periods per second, the resistance, measured by a Wheatstone bridge, being three ohms?

We have $d = 2$; $d^2 = 4$; $\frac{1}{T} = 80$; $\frac{d^2}{T} = 320$.

From the table we find for this value (320) that $k = 1{\cdot}0805$.

Then $R_A = R_c\,k = 3 \times 1{\cdot}0805 = 3{\cdot}2415$ ohms.

If the value $\frac{d^2}{T}$ is not in the table, take the value next above. The error is in excess. The table is sufficiently extended for practical purposes, as it will give values up to 130 periods, and diameters up to 15cm.

When the quotient $\frac{d^2}{T}$ is over 32,000, the effective resistance is obtained with great precision by substituting for the solid a tubular conductor of the same external diameter and thickness equal to

$$6{\cdot}38\sqrt{T} \text{ centimetres.}$$

These results are for copper of the resistivity 1,597 C.G.S. units. A modification of the formula is necessary for other conductors, but as these are so seldom used, we have given only that part of M. Hospitalier's investigation which is directly practical.

THE PROPOSED PACIFIC CABLE.

During the late tour of Mr. Mackenzie Bowell, the Canadian Minister of Trade and Commerce, through the Australian colonies, a memorandum, drawn up by Mr Sandford Fleming, and containing definite proposals for the construction of a Pacific cable, was submitted by him to the Australian Governments. Copies of the memorandum have reached this country and enable us to form some more accurate idea than has hitherto presented itself of the cost of constructing and maintaining an alternative line of cable communication with the Antipodes.

Mr. Sandford Fleming, who was at one time engineer-in-chief to the Canadian Pacific Railway, has for many years advocated the construction of an entirely British cable across the Pacific.

His views were expressed at the Colonial Conference of 1887, and he is generally recognised as one of the best authorities upon the subject. He is therefore presumably in a position to authenticate the facts of his statement. His scheme embraces four alternative proposals for carrying a cable from Vancouver Island to Australia without landing on any territory which is not under British protection.

By the first route the cable would run from Vancouver Island to Fanning Island, thence to the nearest island of the Fiji group. From Fiji it may run direct to New Zealand and thence to Australia. The distance by this route is 7,145 nautical miles, and the estimated cost of construction £1,678,000.

By the second route the cable would run from Vancouver Island to an unoccupied island known as Necker Island, about 240 miles to the west of the Hawaiian group; from Necker Island to Fiji, and thence to New Zealand and Australia. The distance by this route is also 7,145 nautical miles. The estimated cost of construction is £1,385,000.

By the third route the cable would extend, as in No. 2, from Vancouver Island to Necker Island, and thence to one of the eastern islands of the Gilbert group. From the Gilbert group two branches would extend, one to Queensland touching at the Solomon Islands and having its terminal point at Bowen, one to New Zealand through Viti Levu, the southern island of the Fiji group. The distance by this route is 8,264 nautical miles. The estimated cost is £1,825,000.

The fourth route is identical with the third, except that it leaves out the branch to New Zealand and takes the shortest possible line from Vancouver through the Gilbert Islands to Bowen. The distance is only 6,244 nautical miles, and the estimated expense £1,380,000. But it has the disadvantage of leaving New Zealand dependent upon its present cable communication, and it excludes Fiji altogether from telegraphic connection.

The question of cost is, of course, a very important one. Mr. Sandford Fleming proposes to meet it by constructing the cable as the joint property of the colonies concerned, and raising the capital required on their joint guarantee, at an interest which he places as low as 3 per cent. In order to extinguish, as he thinks it may be necessary to do, the subsidy of £32,400 already paid by some of the Australian colonies to the Eastern Extension and payable until May, 1899, he proposes to purchase an annuity of the required amount for those years, and thus adds a capital outlay of £145,000 to the sum required for the construction of the cable. If this arrangement be applied to No. 2 route, the capital required will be £1,745,000, and interest at 3 per cent. will bring the annual charge to £52,350. Mr. Sandford Fleming has, he says, obtained estimates from the best authorities of the cost of working the Pacific cable under Government. These estimates include the salaries of all officials, the cost of two steamers for current repairs, and allowances for all necessary expenses at the terminal and mid-ocean stations, and the highest figure which they have been calculated to reach is £60,000. Besides working expenses it is proposed to establish a renewal fund of 2 per cent. on the cost of the cable, or £32,000 a year. The total estimated expense, including interest upon the capital, amounts, therefore, to £144,350 a year.

Against this outlay Mr. Sandford Fleming puts a carefully detailed calculation of possible revenue. He bases his calculation on the assumption that a Pacific cable may hope, when it is in complete working order, to take at least half of the messages now sent over the lines of the Eastern Extension Company. The number of words transmitted by that company last year was 1,275,191. Dividing this into equal parts, he takes 637,595 words as representing the probable business on which the Pacific cable would begin. But there is the increase of business to be taken into account. This experience is shown to be greatly stimulated by low charges, and from this cause alone, without taking into consideration the expanding trade of Australia and America, Mr. Sandford Fleming estimates that the normal increase will be much faster than it has been hitherto over the lines of the Eastern Extension Company. The charge per word of the Eastern Extension Company until May 1, 1891, was 9s. 4d. The normal increase under that tariff was 14 per cent. per annum. From May 1, 1891, until January 1 last the charge was 4s. a word. To have completely recouped themselves for the loss in fees, the expansion of business of the company should have been a little more than 100 per cent. As a matter of fact it was only 54 per cent. This was, however, enough to show that under a low tariff a considerably more rapid rate of increase may be reasonably counted upon. The charge which it is proposed to make over the Pacific cable is 2s. a word. Thus messages would pass by that route from Australia to England for 3s. 3d. a word instead of 4s. 9d., which is the present charge of the Eastern Extension Company. Putting aside, however, any fanciful estimate which might seem to be justified by these considerations, and basing his calculations on the assumption that business may stand still for three years and will afterwards continue only to increase at the normal high tariff rate of 14 per cent., Mr. Sandford Fleming works out the following table of the estimated earnings of the cable:

Year.	Words per [illegible]	Earnings at 2s. per word.	Year.	Words per [illegible]	Earnings at 2s. per word.
1894	637,595	£63,759	1900	1,175,176	£117,318
1895	726,858	72,686	1901	1,262,439	126,244
1896	816,122	81,612	1902	1,351,703	135,170
1897	905,386	90,539	1903	1,440,967	144,097
1898	994,649	99,465	1904	1,530,230	153,023
1899	1,083,913	108,391			

It is scarcely to be supposed, as Mr. Fleming points out, that the line will be in working order before 1896, and according to this estimate the business done in 1897 would be £90,539; that is to say, in the first year following the establishment of the line the business done might be expected to cover the whole of the working expenses, and to give £30,539 for the renewal fund. After only seven years of working the business done would amount to £144,097, the scheme would be self-supporting, and the contributing Governments would be relieved from any further financial charge. Long before the expiry of the 25 years for which it has been usual to ask for a subsidy the possession of the cable would have become a source of public revenue.

It appears from a further statement included in Mr. Sandford Fleming's memorandum that five of the Australian colonies have in the past two years paid in the form of subsidy and guarantee to the Eastern Extension Company something more than the £52,000 which it is proposed to secure under a joint colonial guarantee in the scheme for a Pacific cable. It is hardly conceivable that, if such a cable were constructed, the Imperial Government would stand aside from contributing its reasonable share. The total amount of the guarantee to be borne by each Government concerned would therefore be relatively small, and as far as Mr. Sandford Fleming's estimates are to be trusted, there is nothing extravagantly impossible in the figures. It is understood that a conference will shortly be held in Canada for the purpose of discussing the scheme more fully, and if it be found to bear the examination of experts, steps will be taken to procure the assent of all the colonial Governments concerned.—*The Times.*

PHYSICAL SOCIETY.

At a recent meeting of the Physical Society (Prof. A. W. Rücker, M.A., F.R.S., president, in the chair), Messrs. J. H. Gillett and F. Hovenden were elected members of the society.

The **President** announced that Mr. Preece's note on the "**Specific Resistance of Sea-Water**" had been temporarily withdrawn.

Prof. G. M. Minchin, M.A., made a communication on the "**Calculation of the Coefficient of Self-Induction of a Circular Current of Given Aperture and Cross-Section.**" Instead of assuming the cross-section of the wire small and the current density constant over the section, as is usually done, the author takes into account the dimensions of the section and the non-uniform distribution of the current. Making use of the expressions for the vector potential, G, of the current given in his previous papers (*Philosophical Magazine*, April and August, 1893), the author calculates the total normal flux of force through a surface intersected once in the positive direction by every tube of force emanating from the given current. This flux divided by the current gives the coefficient of self-induction. The surface chosen is the circular aperture of the current and half of the anchor ring formed by the wire. When the current density is inversely proportional to the distance from the axis of the circular current, the value for the coefficient of self-induction is found to be

$$\pi\left\{4a(L-2)+2c\left(L-\frac{5}{4}\right)-\frac{c^2}{16a}(2L+19)\right\},$$

where a is the radius of the central filament of the current, c the radius of the cross-section of the wire, and $L = \log_e \frac{8a}{c}$. Clerk-Maxwell's approximate expression agrees with this in the principal term. As an example of the closeness of the approximation, the case of a current in a wire two millimetres diameter bent to a circle of two centimetres mean diameter had been taken, the approximate and corrected coefficients being 58·868 and 59·206 absolute units respectively. When the current in the wire is superficial, as in the case of alternating currents of high frequency, the coefficient is somewhat greater, being given by the expression

$$\pi\left\{4a(L-2)+2c\left(L+\frac{3}{2}\right)+\frac{c^2}{16a}(4L+11)\right\}.$$

Incidentally it was pointed out that the function, Gx, where G is the vector potential at a point distance, x, from the axis of a circular current, was the same as Stokes's current function in hydrodynamics.

Another paper on the "**Magnetic Field of a Current Running in a Cylindrical Coil,**" was read by **Prof. Minchin.** The cylindrical coil is regarded as a series of equal circles lying close together and forming a cylindrical surface. Replacing each circular current by its equivalent magnetic shell, the problem of finding the magnetic potential at a point resolves itself into calculating the gravitational potential due to two circular plates of attracting matter, one positive and the other negative, situated respectively at opposite ends of the cylinder. The magnetic potential due to one plate is then deduced in terms of elliptic integrals of the first, second, and third kinds. The president had pointed out that the expressions given in the printed proof of the paper only applied when the perpendicular from the point to the plate fall within the circle. The author had, therefore, modified the formula so as to be true generally. From this formula the equipotential curves can be constructed. The same system of curves serve for the plate at the other end of the cylinder by changing the signs of the numerals representing the potentials and giving the curves a motion of translation equal to the length of the cylinder in the direction of its axis. The equipotential curves for the coil can then be deduced by drawing through the points of intersection of the two sets of curves whose numerical values have a constant sum. In determining the curves the author had to calculate tables of elliptic integrals of the third kind, and these he hoped to complete

before the paper was published. In reply to a question on the first paper which had been brought before him by Prof. Perry, the author said that as the diameter of the wire diminished indefinitely, both the self induction and resistance became infinite, but the ratio, L/R, became zero. It was interesting to examine what relation between the aperture and cross section gave minimum impedance. If the ordinary expression for L be taken the problem was impossible, but the corrected form admitted of a solution. **Prof. Perry** hoped the work Prof. Minchin had done so well for circles and cylinders would be extended to cylindrical coils of rectangular cross section. It was most important to be able to find the shape of the field produced by such coils. **Prof. S. P. Thompson** enquired if there was any way of deducing the expression for the magnetic force at a point other than that given in the paper on the "Magnetic Field of a Circular Current" (*Philosophical Magazine*, April, 1893). In reply, **Prof. Minchin** explained how the formula followed at once from the fundamental theorem that magnetic force is the curl of the vector potential. This was based on Laplace's expression for the force between a magnetic pole and an element of current, which had been proved experimentally.

A paper, by **Mr. J. Swinburne**, was then read on "**A Potentiometer for Alternating Currents.**" This was given in our last issue.

BUSINESS NOTES.

Hyde Park.—The St. George's Vestry intend to introduce the electric light in the conveniences at Marble Arch.

Penrith.—The Penrith Board of Health have agreed not to proceed for 12 months with the proposed application for electric lighting powers.

Tunbridge Wells.—Mr. W. H. Preece is preparing plans and specifications for the new buildings, machinery, and central station for the Town Council.

Wolverhampton.—The Corporation invite tenders by January 2 for a complete travelling crane, and by January 1 for the erection of an electric light station.

Renfrewshire.—The contract for lighting Houston House, Renfrewshire, for Lady Anne Speirs, has just been given to Messrs. Tayler, Smith, and Co.

Change of Address.—Major General Webber, C.B., consulting electrical engineer, has removed his office from Portland House, Basinghall street, E.C., to 27, Chancery lane, W.C.

Port Talbot.—A proposal to form a sub committee to consider the question of the lighting of the district of the Margam Local Board will be moved at the next meeting of the latter.

Breach of the Factory Act.—The West Hartlepool Steel and Iron Ore Company were on Wednesday fined £5 and costs for a breach of the Factory Act, in not having the engine driving the electric plant protected.

Aluminium Company.—The petition by the Aluminium Company for the reduction of its capital from £400,000 to £80,000, by reason of loss of capital, has been renewed. Mr. Justice Wright has granted leave to amend the petition.

Huddersfield.—Mr. Calvert, in moving the adoption of the minutes of the Electric Lighting Committee of the Town Council, mentioned last week that in a few days they would be able to double the supply of current for public lighting.

Blackpool.—Mr. T. Parker has made an examination of the Blackpool tramway, and will report on its condition to the Corporation. An installation of the electric light is in progress at Messrs. Garlick and Sykes's office, the first of its kind in the town. Messrs. Challoner are carrying out the work.

City and South London Railway.—The receipts of the Company for the week ending December 24 were £950, against £926 for the same period last year, or an increase of £24. The total receipts for the second half year of 1893 show an increase of £167 over those for the corresponding period of 1892.

Chiswick.—At the last meeting of the Local Board the clerk read a document from the Board of Trade, together with a copy of the proposed regulations for the electric lighting of Chiswick. The letter was referred to the Works Committee, the surveyor being instructed to look into the matter and report.

Newport.—A deputation from the County Council have paid a visit to Bristol and inspected the electric light station on the Welsh Back and the installation as far as it has progressed, in the city of churches. The committee got a good notion of how to deal with narrow streets such as are in evidence in Newport.

Nottingham.—Mr. W. J. Furse, who for the past 12 years has held the position of engineer and manager for Mr. Joseph Blackburn, has resigned his position, and bought the business of the late Mr. Josiah Till, Burton street, Nottingham, manufacturer of lightning conductors, etc., and will continue the business on his own account at that address.

Acme and Immisch Electric Works, Limited.—This Company has been registered with a capital of £25,000 in £1 shares. The object is to amalgamate the undertaking of the Acme Works, Chalk Farm, N.W., and the General Electric Power and Traction Company, Limited, of Kentish Town, N.W., and to carry on business as electrical and mechanical engineers, etc.

Dundee.—At a meeting of the Dundee Police Commission, Mr. Ballingall called attention to a minute regarding the lighting of the central police buildings by electricity. He said that they had not yet received a comparative statement as to the cost of the electric light and the cost of gas. The approval of the minute was moved by Treasurer Willsher, and the minute was adopted.

Richmond.—The Richmond (Surrey) Town Council have referred back to the Electric Lighting Committee a proposal that the electric light should be adopted for illuminating certain streets in the town, and that a contract should be made with the Richmond Electric Light Company. The latter has been formed, with a capital of £50,000, to take over the powers of Messrs. Latimer Clark, Muirhead, and Co., Limited.

Swansea.—Tenders are invited by January 4th by the Swansea Harbour Trustees for the working, maintenance, and renewal of the electric light machinery and plant for five years (subject to earlier determination by the trustees). Particulars and forms of tender may be obtained on application to the trustees' engineer, Mr. A. J. Schenk. Tenders, sealed and addressed to Mr. Talfourd Strick, clerk, Harbour Offices, Swansea, and marked on the outside "Tender—Electric Lighting," should be delivered at the Harbour Offices, Swansea, by the date mentioned.

Messrs. Robey and Co.—We are informed that Messrs. Robey and Co., engineers, of the Globe Works, Lincoln, have converted their business into a limited liability company, with an authorised share capital of £300,000 in preference and ordinary shares, £272,710 of which are taken by the partners and holders of capital in the old firm, no issue of any of the Company's share capital having been offered to the public. In addition to the above capital of £300,000, there will be an issue of £125,000 4½ per cent. debentures—making a total capital of £425,000. This change has been made in consequence of the deaths of partners, and to facilitate family arrangements, leaving the present management of the business unaltered.

Llandudno.—The Town Improvement Commissioners have received a letter from Messrs. R. Bellis and W. Kingsland, submitting a scheme for the introduction of the electric light into Llandudno. They were prepared, with the sanction of the Commissioners, to take immediate steps to form a company of local gentlemen and apply to the Board of Trade for a provisional order. It was decided to consider the subject at a special meeting to be held in January, the clerk in the meantime to report what effect such companies have had on other towns; also to write to Messrs. Bellis and Kingsland, enquiring on what terms, if the Board favoured the proposal, they would be prepared to transfer their undertaking when it had been fully established.

Lighting at Prescot.—It is alleged that the electric lighting of the town is defective. A special meeting of the Local Board was held last week to receive a report from the surveyor and assistant surveyor as to the public lighting. The surveyor (Mr. Goldsworth) read a report on the subject, and a letter was received from the managing director of the British Insulated Wire Company, Prescot, who have the contract for the lighting, saying that the defects in the lighting would be remedied without delay. A resolution was passed appointing Mr. Dyson and the surveyor to wait upon the managing director of the Wire Company to point out the serious inconvenience arising from a certain number of lamps not being lighted, and to ascertain how soon the defective lighting would be remedied.

Coventry.—The Town Council have adopted the report of the Electric Light Committee. The committee reported that Mr. R. Hammond had attended the committee meeting and submitted specification and general conditions for the installation of the generating and distributing plant, and the same were considered and settled by the committee, the amount of the contract being £9,185, the trenching of the streets to be left in the hands of the Corporation. It was ordered that the amount of security to be given by the contractors be £2,000. At the same meeting a letter from Messrs. Fowler, Limited, Leeds, was read. The letter stated that Mr. Hammond was not now, and never had been, a shareholder in the company, and he had not, and never had had, any pecuniary interest in it.

Personal.—A marriage has recently taken place between Mr. Ernest George Tidd, A.M.I.C.E., A.I.E.E., of Glasgow, and Miss Helen Kate (Nellie) Bond. Mr. Tidd has for the last five years been on the staff of Messrs. Paterson and Cooper, and as engineer of their contract department has superintended some of the large installations recently erected by them. He has lately left London for Scotland as manager of Messrs. Paterson and Cooper's ship-lighting and Scotch branches at 137, West Regent street, and Maritime buildings, Dundee. Mr. Tidd was presented with a handsome hall gong by Messrs. Paterson and Cooper's London outdoor employés.—We understand that Mr. H. G. Massingham is no longer on the board of directors of the City of Bath Electric Lighting and Engineering Company, Limited, and that Mr. J. Bigland Wood is a new director.

Lighting of Fleetwood.—A special meeting of the Improvement Commissioners has been held to consider the chairman's report with reference to the electric lighting scheme, and to which reference was made in our last issue. The Chairman considered that every praise was due to the committee. He firmly believed the committee had arrived at the best conclusion possible. Mr. Davies endorsed these remarks. Mr. Davies moved, and Mr. Leadbetter seconded, that the Brush Company's tender for the necessary plant at about £9,000 should be accepted, subject to the consent of a public meeting of ratepayers, the Board of Trade, the Local Government Board, and the Postmaster General. The resolution was carried unanimously, and it was decided to give the requisite instructions for the preparation of plans, etc., required for the electric lighting station and gas tank in the town's yard, London street, together with the construction of transformer-chambers in streets, the committee being empowered to invite

applications for the appointment of a resident working electrical engineer. The Clerk said a town's meeting would probably be held early in January.

Bournemouth.—The Town Council have adopted the report of the Lighting Committee, who stated that they had received a deputation, consisting of Messrs. Leveson Scarth and J. A. Hosker, on behalf of the Bournemouth and District Electric Supply Company, the deputation pointing out to the committee the amendments suggested by the company in the draft license, and stating that those suggestions should be communicated to the town clerk in writing. This having since been done, the committee recommended the Council to agree to certain literal alterations in the wording of the license. The report, as mentioned, was adopted. Replying to Councillor Jenkins, as to whether the electric light company had a monopoly in Bournemouth, the Town Clerk explained that they had a monopoly to the extent that no private individual or company were able to generate and supply electric light without a provisional order or license, and that such was not likely to be granted if the present company carried out their work satisfactorily. The Corporation, however, in their license took powers to provide public lighting for their own purposes, and had power to purchase the works of the company on certain conditions.

Result of Sunderland Tenders.—The Highways Committee of the Corporation has had under consideration the tenders for supplying the plant for the introduction of the electric light. The following have been accepted: Boilers and mountings, Messrs. Hawksley, Wyld, and Co., Sheffield, £1,380; engine and dynamos, Messrs. J. H. Holmes and Co., Newcastle, £4,340; alternators, Crompton and Co., Chelmsford, £1,352; batteries, Electrical Power Storage Company, £763; insulated cables, India Rubber Works, Silvertown, £2,592; road work, Mr. G. Simpson, Newcastle, £2,590; ironwork, Messrs. McLaren, Glasgow, £296; stonework, Messrs. Wilks and Maplebeck, Birmingham, £236. The total amount of the tenders is £15,074, against a sum of £21,000 estimated. On Wednesday, the Highways Committee, at the fortnightly meeting of the Sunderland Council, recommended the acceptance of the eight tenders for carrying out the work necessary for the introduction of electric lighting, and that the Finance Committee be directed to borrow £25,000 in connection with the same. Alderman Bell moved, and Alderman Wilson seconded, the adoption of the report, which, after some discussion, was adopted.

Woodhouse and Rawson, Limited.—A meeting of the creditors and debenture holders in Woodhouse and Rawson United, Limited, was held last week to consider the scheme of reconstruction propounded under the winding-up order. Mr. C. J. Stewart, the official receiver, presided, and stated that, according to the books of the Company, there was £28,000 still unaccounted for. The directors estimated a surplus of £29,636, but three of the directors—Sir Wm. Rawson, Mr. Samuel Pope, Q.C., and Mr. A. L. Foley—said they did not hold themselves personally responsible for that statement. He understood that it was extremely doubtful whether the debenture holders would receive 20s. in the £. They must, he said, look with extreme doubt on the statements as to the reconstructed Epstein Electric Company, and his estimate was that there would be nothing for the unsecured creditors and that there would be a deficiency of £43,000. Examining the accounts, he pointed out that the gross income in the year ending June 30, 1890, was put down at £109,597, the items including £37,235 in respect of the promotion of the International Okonite Company, Limited, of which company Mr. Samuel Pope became a director, and which had paid one dividend in its first year. He concluded that of the total income in that year only £21,491 could be properly put down to the credit of an industrial enterprise. The expenditure in the same year was £48,512, the loss in 1891 was £43,000, and in 1892 £129,000. Practically, the business that had been the means of giving 15 per cent. to the shareholders for two years had been the promotion of other companies including the Okonite, the Elmore, and Phœnix Companies. The last mentioned company was formed entirely for financial purposes. The business now was whether it was desirable to appoint a liquidator and a committee of inspection. Mr. Pope, Q.C., said he had stuck to the concern both in person and in pocket so long as there was any concern to stick to. He was a director and a large shareholder, and he would lose probably as much as anyone in the room. He would prefer that they should leave the matter in the hands of the official receiver until electric traction was fully developed, and then the creditors would get the benefit of it. Mr. Stewart was appointed the official liquidator, and, after a somewhat warm discussion, a committee of creditors was appointed to act with the committee of contributories in assisting the official liquidator.

Lighting of Chelmsford.—The Town Council again sat in committee last week to consider the provisional order for which Messrs. Crompton and Co., Limited, are applying to the Board of Trade in connection with the electric lighting of Chelmsford. The order would empower Messrs. Crompton to supply electric lighting in Chelmsford for 42 years and to charge for every amount up to 20 units 13s. 4d., each unit over to be charged 8d. The committee saw no objection to this order, provided the price charged to consumers was reduced from 8d. to 6½d. for every unit over 20 units, and provided the company gave an undertaking that they would allow a discount of ½d on every unit over 20 units if the money was paid within a month, and provided a clause was inserted giving the Council the option of purchasing the undertaking at the end of 21 years or 31 years by valuation. Alderman Morton elicited from the town clerk that if this provisional order was granted it would not hinder the local authority under the Act of Parliament from undertaking the public lighting of the town at the expiration of the contract with Messrs. Crompton. Mr. Gray denied that the Council by agreeing to the order would be granting Messrs. Crompton a monopoly, while he reminded the meeting that the Arc Works was an important industry to the town, and the Council should grant every facility to the company that was consistent with the interests of the burgesses. This view was shared by other councillors, Mr Taylor reminding the Council that in this matter they were amply protected by the Board of Trade. Alderman Chancellor moved as an amendment that the period of the provisional order should be reduced to 20 years, but this found no support. Mr. F. Whitmore then moved an amendment recommending the Council to support the order, with the exception of Clause 80 (which deals with the question of purchase). Mr. Gray seconded, and Mr. Maskell withdrawing his motion in favour of it, it was ultimately put to the meeting and carried with only one dissentient. Clause 80 was next discussed. Alderman Chancellor was of opinion that their purchasing powers should be clearly defined, and a clause was finally accepted to the effect that, in the event of a sale, the company should sell to the local authorities all buildings, lands, and plant used for the public lighting of the town. It was also resolved to include a clause giving the Council power to purchase at the expiration of 21 or 31 years, the terms of purchase to be in accordance with conditions specified in Section 2 of the Electric Lighting Act, 1888, and that the Council should only purchase such materials, buildings, plant, etc., as might be necessary for the public and private lighting of the town.

Refuse as Fuel.—In our last issue we referred to a scheme which the Harrogate Corporation has decided to adopt for the drying, sorting, and combustion of refuse, and for its application as a steam generator for the lighting of the town by electricity. In view of the latest development which this question has reached, a representative of a provincial paper paid a visit a day or two ago to the works established at King Cross, Halifax, for testing another appliance—the Livet system of generating steam by the destruction and combustion of town refuse. The correspondent describes the system as follows: The system differs somewhat from that at Harrogate. It involves no drying or sorting, the refuse being put into the furnace just as it comes from the dusthole or rubbish heap, without any preparation whatever. The material is simply a substitute for coal; indeed, not a particle of coal is used, and it is claimed that three tons of the refuse is equal to one ton of the best coal. The boiler is so constructed that it has about double the heating surface of the largest type of Lancashire boiler. Round this boiler flues are arranged in such a manner as to create an enormous natural draught, which enables all classes of fuel to be burnt very economically. In the case of dusthole rubbish and town refuse generally 3lb. to 4lb. of water can be evaporated to every pound of the refuse, and this, it is claimed, without creating either smoke or smell, as the excessive draught in the furnaces causes such perfect combustion, and raises the temperature of the gases to such an enormous heat, that the whole of the impurities are entirely destroyed. The consumption of rubbish per foot of grate surface super is very large, and enables a great amount of the material to be got rid of. At the same time, assuming that the whole of a town's refuse is utilised in this way, it is contended that the evaporation will produce enough steam power to light the whole of the town by electricity. The object at which this apparatus aims, in addition to the destruction of the refuse, is the generation of steam. Of course, the steam can be adopted for any purpose, but the most obvious use to which a corporation would put it would be that of driving electric lighting dynamos. It is said that three boilers like the one erected at Halifax would enable the whole of that town and its suburbs to be illuminated with the electric light. In order to demonstrate the efficiency of the system a powerful steam dynamo has been fixed in connection with the boiler, and the works lighted by means of a number of incandescent and arc lamps. But the most brilliant effects are produced by means of a dazzling searchlight of 25,000 c.p. The illumination now produced is said to represent but a tithe of the capabilities of even the one boiler now in use. The works have only just been completed, and an opportunity will soon be afforded to representatives of the corporations, steam users, and other interested in the question to see the apparatus in operation.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¾
– Pref.	—	2¾
Charing Cross and Strand	—	6
City of London	—	11¼
— Pref.	—	13
Electric Construction	—	1¾
House to House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22¼
Liverpool Electric Supply	5	6¼
	3½	4¾
London Electric Supply	5	1
Metropolitan Electric Supply	—	8
National Telephone	5	4¾
St. James', Pref.	—	8¼
Swan United	3¾	3¼
Westminster Electric	—	5¼